DIMENSIONS NBS

The magazine of the
National Bureau
of Standards
U.S. Department
of Commerce

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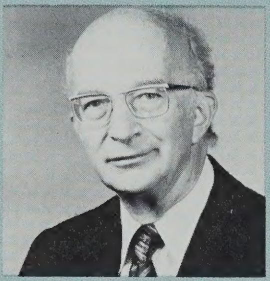
ANNIVERSARY

NBS THROUGH THE YEARS. See page 2.

COMMENT

MATHEMATICAL MODELING FOR MANAGERS



I welcome this opportunity to comment on the characteristics of contemporary mathematical modeling. The feature article of this issue describes a most successful example of large-scale mathematical modeling carried out in the Center for Applied Mathematics. I will use it as a case study to illustrate my comments.

First of all, the subjects—salmon fisheries, hatchery management, international treaties, State fishery regulations, Indian tribes, profits for salmon troll fishers—may seem unlikely topics for mathematical analysis. Yet this is typical of the pervasiveness of today's mathematical modeling activities.

In the article on the Columbia River Model, the writer has nicely suggested the varied biological, physical, economic, sociological, management, and political parameters incorporated in a useful fisheries model. Typically, mathematical models of today are interdisciplinary, taking into account the interplay among physical, biological, engineering, economic, political, and other factors, all of which must be considered in management decisions. The mathematical consequence is that the model must deal with many variables. This is quite in contrast to early models in the physical sciences which often dealt with relatively few variables.

A second obvious comment is that such models of richly varied real-life situations do not, and should not, produce a unique "correct" solution or a single "best" answer. Rather, the model contributes a realistic quantitative comparison of many possible alternatives. These comparisons allow us to measure the consequences of changing the controllable parameters. The fisheries model evaluates the role of literally thousands of parameters. Even the smaller parameter set, characterizing (controllable) management decisions, includes about 100 parameters. To evolve a useful model of such a complicated situation requires the imposition of numerous real-life constraints. In the fisheries model, for example, 25 percent of the management parameters are highly constrained.

An obvious need in such a multiparameter model is for data—good data, usually large gobs of data—to validate and evaluate the model. The data base for the fisheries model is very large and its treatment benefits from the use of the most modern data base management techniques of computer science and state-of-the-art methods of statistical data analysis.

Again, with many variables, many constraints, and many possible scenarios of interest, some form of optimization is usually necessary to identify those alternatives that are "better" than others. Such optimization is accomplished by sophisticated methods of multi-variate constrained optimization—usually some form of linear or nonlinear programming. Optimizations of this kind are indeed used in the Columbia River Model.

Finally, the model is useful only if it is understood and accepted by those who use it. To achieve this understanding requires collaboration with the users at all stages of model development, backed up by documentation clearly understood by both user and specialist modeler. This has been done in the fisheries modeling studies. Policy-making officials at the State, national, and international levels—possessing no mathematical expertise—have used the fisheries model to assess the implications of many different management or regulatory approaches.

Many of the techniques required to solve such large-scale modeling systems lie at the forefront of new research in present-day mathematical science areas. Naturally this makes modeling an exciting activity at the research frontier for workers in the mathematical sciences and computing.

Of course the fisheries formulation, like most mathematical models of consequence, did not develop overnight. Johnson's model represents years of careful formulation, analysis, testing, evaluation, and validation carried out in collaboration with experts in fisheries management, biology, hatchery operation, and many other specialties. A number of cycles of problem reformulation, analysis, testing, validation, and evaluation have brought it to a stage of realistic, feasible, understandable and accepted use.

In the Center for Applied Mathematics at NBS, this fisheries modeling is but one of many different kinds of modeling activities in which the staff is involved. In collaboration with our NBS colleagues, we are studying models of the flow of heated air in a room fire, the stochastic behavior over time of an ensemble of cesium beam atomic clocks, the determination of super-accurate satellite orbit positions, and the behavior of nonlinear electronic oscillators. Other models describe polymer crystallization, fatigue and fracture of metals, plastics, and ceramics, the solidification of metal alloys, the mid-term supplies of U.S. oil and gas, and the multi-mode transportation network of the continental United States.

If you would like to have further information, discussion, or (incredibly!) wish to argue some point, please feel free to contact me.

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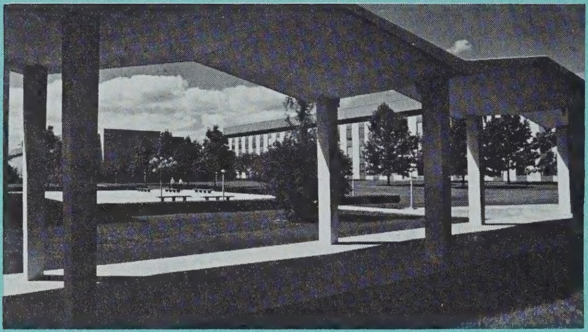
Contents

ARTICLES

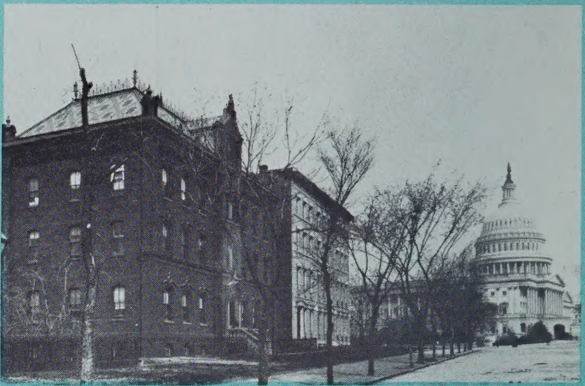
INTERFACE

UPDATE

COVER STORY

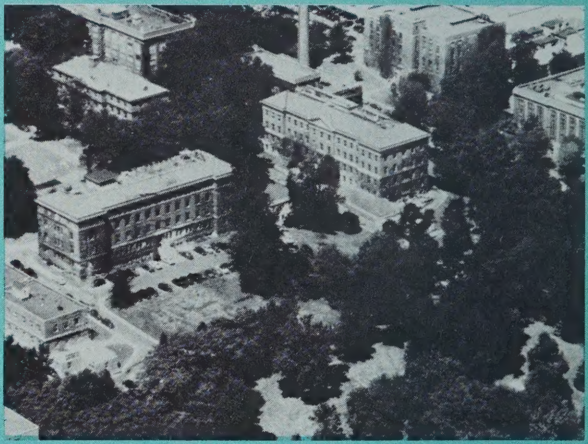


Laboratory buildings at NBS Gaithersburg.



First home of NBS (1901-1903) was in part of Coast and Geodetic Building within view of the Capitol.

Aerial view of NBS grounds in Gaithersburg, Md.



NBS main home from 1903-1966—corner of Van Ness and Connecticut Ave., Washington, D.C.

Aerial view of NBS laboratories in Boulder, Colo.

NBS facilities in Gaithersburg, Md.

NBS Boulder laboratories.

NBS Through the Years

Gateway to Progress

THIS year the National Bureau of Standards is celebrating its 80th anniversary, and in commemoration DIMENSIONS takes a pictorial look at some notable moments from the past.

When the Bureau was founded in 1901, America was fast becoming a world power. However, many in science, industry, and government were concerned that the lack of a Federal measurement standards laboratory was seriously limiting growth in U.S. industry and commerce. Inaccuracies in railroad scales caused disputes about taxes and charges. Scientists had to look to Europe for precision-making instruments, and even those produced in this country had to be calibrated abroad. And manufacturers lacked standards for quality control in the production of materials and products.

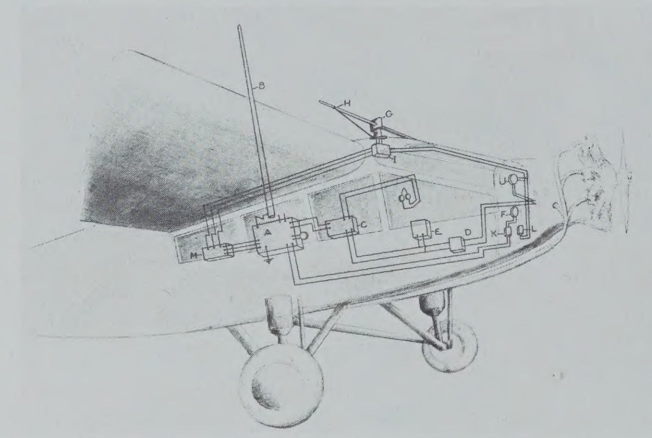
So, when Secretary of the Treasury Lyman J. Gage asked Congress to establish a "Standardizing Bureau," there was little opposition. In the spring of 1900, the House Committee on Coinage, Weights and Measures reported, "No more essential aid could be given to manufacturing, commerce, and the makers of scientific apparatus, the scientific work of the government, of schools, colleges, and universities than by the establishment of the institution proposed in this bill." Ten months later the bill founding NBS passed both houses of Congress and was signed by President McKinley on March 3, 1901.

Throughout these 80 years, NBS has brought harmony to measurement practices in commerce through uniform, legal weights and measures. Its research has laid the groundwork for many advances in electricity, aviation, automotive engineering, and materials such as plastics and building materials. It has provided essential improvements in electrical standards and developed better standards of length and new standards of light, temperature, and time. The Bureau has pioneered work in the areas of aeronautics, radio, and cryogenics to name a few.

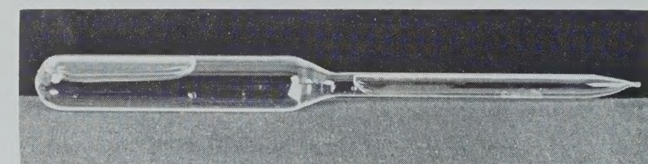
Today, as increasingly complex industrial processes, manufacturing technology, and science demand degrees of precision, based on accurate measurement, far beyond the range practiced by the Nation's scientists at the turn of the century, NBS continues to provide the necessary basic standards, measurement techniques, and research results. □

SOME HIGHLIGHTS OF NBS SCIENTIFIC ACCOMPLISHMENTS

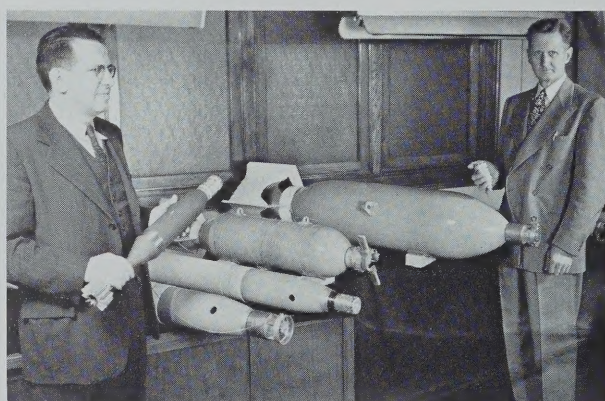
1904—NBS demonstrated the first neon tube; it was later commercialized and a new industry was founded.
1914—NBS made a classical determination of the faraday, an important physical constant; later this was replaced by a more precise determination by NBS.
1915—NBS developed a radio direction finder; this is a principle now used by all commercial airlines.
1922—NBS developed the first crystal rectification filter circuit unit enabling radio to operate on household current.
1929—First visual-type radio beacon was invented by NBS electronics genius Harry Diamond.
1930—NBS provided a redetermination of the gravitational constant.
1934—NBS performed laboratory fractionation of heavy water, providing the experimental basis for Urey's work on hydrogen isotopes, which won him the Nobel prize in chemistry.
1938—NBS greatly increased the accuracy of measurement of temperature, humidity, and atmospheric pressure in radio meteorography, supplying the standard for present-day radiosondes.
1944—NBS developed the first successful guided missile, the only automatic homing guided missile carried into large-scale production and used in World War II by the United States.
1946—NBS developed the basis of the multimillion dollar industry in electrodeless plating of nickel.
—NBS introduced printed circuit techniques, first used in production of radio proximity fuzes, now widely used in the manufacture of electronic assemblies.



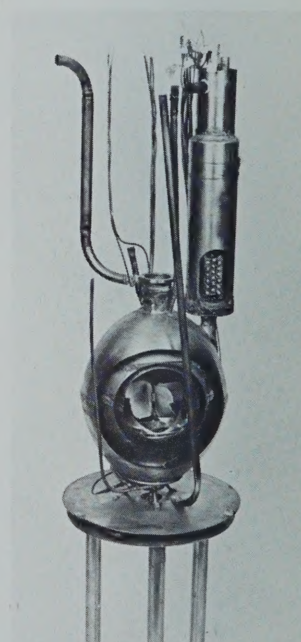
Sketch showing installation of radio equipment designed for aiding blind landings (1929).



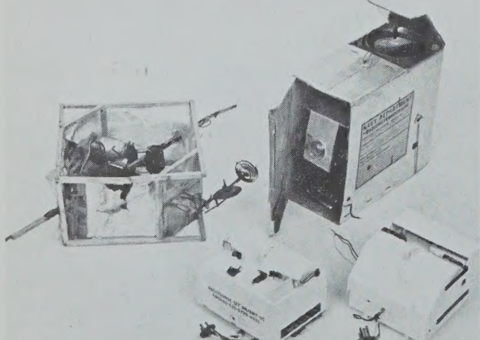
Early sample of heavy water (1934).



Five different types of radio proximity fuzes mounted on the weapons for which they were designed by NBS. (Left) Harry Diamond, Chief of the NBS Ordnance Development Division, holds the mortar fuze mounted on an 81 mm mortar shell. (Right) Alexander Ellett, Chief of Division 4 of the National Defense Research Council, holds the mortar fuze unmounted (1946).



Water calorimeter (1937), precursor of modern version used for measuring high-energy radiation from electron accelerators (1978).



Radiosondes (1935) used for accurate humidity measurements in weather studies.

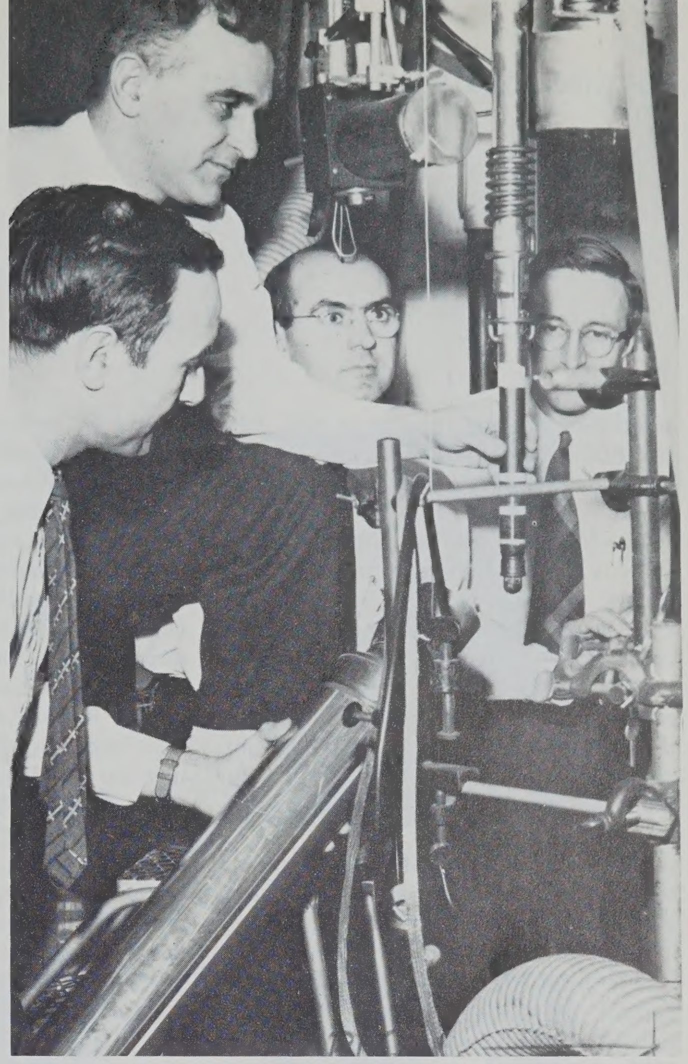
1949—NBS developed the first atomic clock, paving the way for later versions now in use in NBS and elsewhere.

1950—NBS dedicated the first automatically sequenced, high-speed, digital computer with internal memory in the United States—SEAC.

1958—NBS redetermined the gyromagnetic ratio of the proton by measuring the precession rate of protons in a magnetic field. The new value made more accurate evaluation of fundamental constants possible.

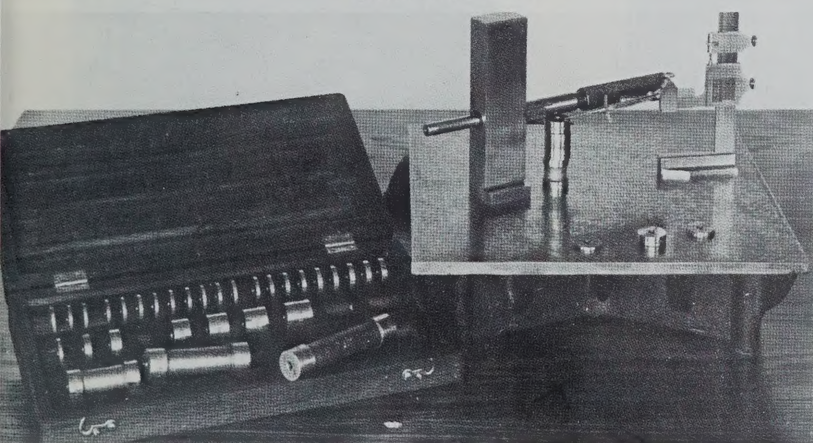
1963—NBS established the National Standard Reference Data System for dissemination of data on physical and chemical properties of materials.

1971—A system called TV Time, developed by NBS engineers, allowed time for frequency information to be broadcast on TV channels without disturbing regular shows. A later application to TV programs



NBS physicists (l to r) Ralph Hudson, Ernest Ambler (now Director of NBS), Dale Hoppes, and Raymond Hayward with equipment used in demonstrating questionability of parity conservation concept in quantum mechanics (1956).

Precision gage blocks essential to manufacture of interchangeable parts were provided by NBS in World War I.



Antenna used in experimental time broadcasts, part of a program begun at NBS over 50 years ago to broadcast standard frequencies.

Physicist David J. Glaze is shown making adjustments to NBS-6, part of a complex system of primary and secondary time/frequency standards maintained in the Boulder laboratories (1971).

High-speed air-turbine dental drill evolved from NBS-American Dental Association cooperation.

aided the deaf and resulted in NBS, PBS, and ABC receiving Emmy's for "outstanding achievement in engineering development."

1975—NBS established baseline data for analysis of trace hydrocarbons in Alaskan waters; this base will be used as a reference in monitoring future environmental contamination trends.

—NBS developed the first laser excited micro-Raman spectrometer for identifying the chemical species of small (1 to 3 μm), discrete particles encountered in air pollution from urban dust, fossil fuel, industrial processes, and wear.

—A memory device called the Cerebellar Model Arithmetic Computer, simulating the human brain's subconscious computing centers, was demonstrated. The device is suited for automated machine tool control, robot manipulation, and neurological behavioral research.

1977—NBS developed a novel ultrasonic imaging device called a Sono-Chromascope of unprecedented sensitivity and resolution and suited for quantitative diagnosis and analysis of tumors and other pathologic tissues.

—NBS developed oil fingerprinting techniques for identifying the source and date of oil spillage.

—NBS joined with Underwriters Laboratories in developing the first performance standard for residential smoke detectors. This was subsequently adopted by Canada and Australia and was the first such standard proposed to the International Standards Organization for international use.

—NBS developed a series of microelectronic structures to be used by U.S. industry in measuring a variety of semiconductor material and fabrication process parameters.

1977 to 1980—NBS published the Federal Data Encryption Standards for use in cryptographic protection of valuable, sensitive, and private computer information during transmission and storage.

1978—NBS developed an accurate method for measuring the volume of supertankers used to transport liquid natural gas (LNG) to assure an equitable exchange (about $6 million per cargo ship at the 1978 exchange rate).

—Test procedures were developed for determining the efficiency of insulation used in attics and similar installations.

—A water calorimeter, for measuring high-energy radiation from electron accelerators, affords the opportunity for reducing patient dosage uncertainties from 5 to 1 or 2 percent.

—The Federal Bureau of Investigation (FBI) began using an automatic fingerprint matcher developed at NBS for the FBI.

1979—Three Federal computer interface standards for input/output channel level interfaces of all medium and large-scale computer systems were provided to cut costs to the Government of new computer peripherals.

1979 to 1980—NBS developed linewidth measurement methodology and artifacts for *in situ* calibration of process instrumentation and research equipment by the semiconductor integrated circuit industry.

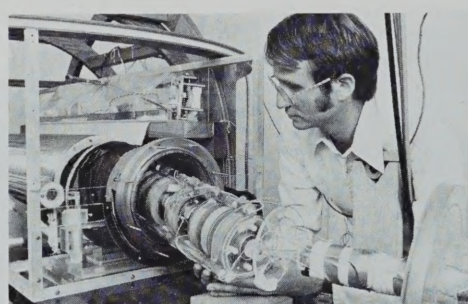
1980—NBS developed a novel research tool for studying corrosion under organic coatings; it can be used to evaluate the effectiveness of corrosion-inhibiting pigments and to identify mechanisms in corrosion.

—A transpiration mass-spectrometer was developed to allow sampling of high pressure and temperature vapors and permit analysis that is important to the development of gas turbines, MHD power generators, coal gasifiers, and boilers fired with fossil fuels.

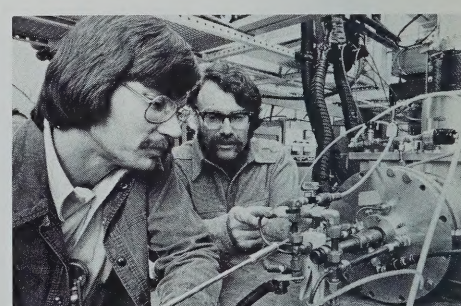
—NBS prepared fluorophosphate glasses with the superior nonlinear indices needed to transmit the high-energy laser pulses used in inertial fusion energy development.

—NBS developed a surface magnetometer capable of measuring the magnetization of the outer layers of atoms in a crystal.

—Over 40 000 Standard Reference Materials were distributed, mainly to support industrial quality control and productivity.

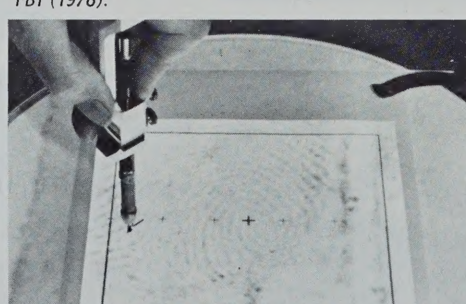


Edwin R. Williams examines part of apparatus used to redetermine the gyrometric ration of the proton by measuring the precision rate of protons in a magnetic field (1958).

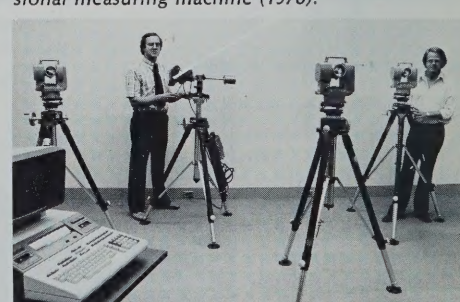


Chemists David Bonnell (left) and John Hastie examine their transpiration mass-spectrometer (1980).

Fingerprint matcher developed at NBS for the FBI (1978).

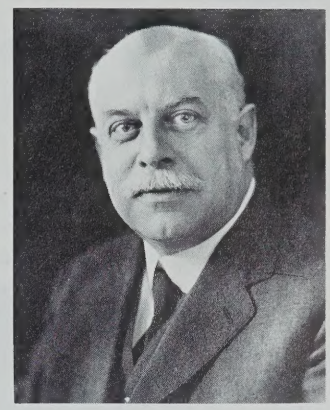


William Haight and Robert Hocken demonstrate use of components of the large-scale 3-dimensional measuring machine (1978).

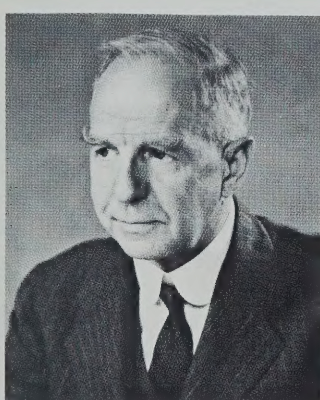


NBS Directors

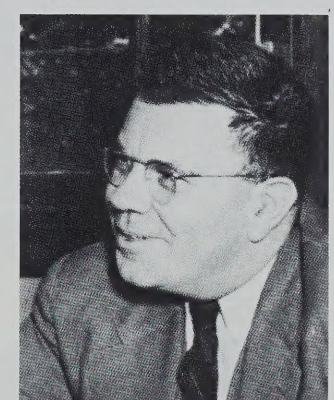
Samuel Stratton
1901-1922



George Burgess
1922-1932

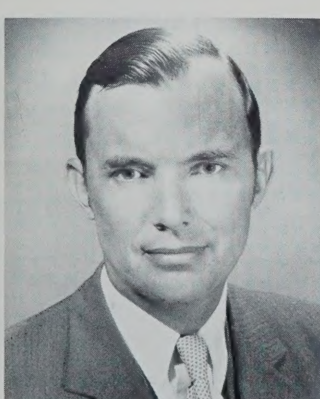


Lyman Briggs
1932-1946



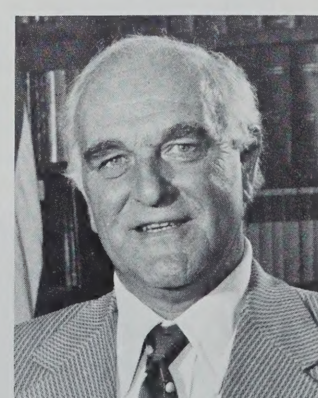
Edward Condon
1946-1951

Allen Astin
1951-1969



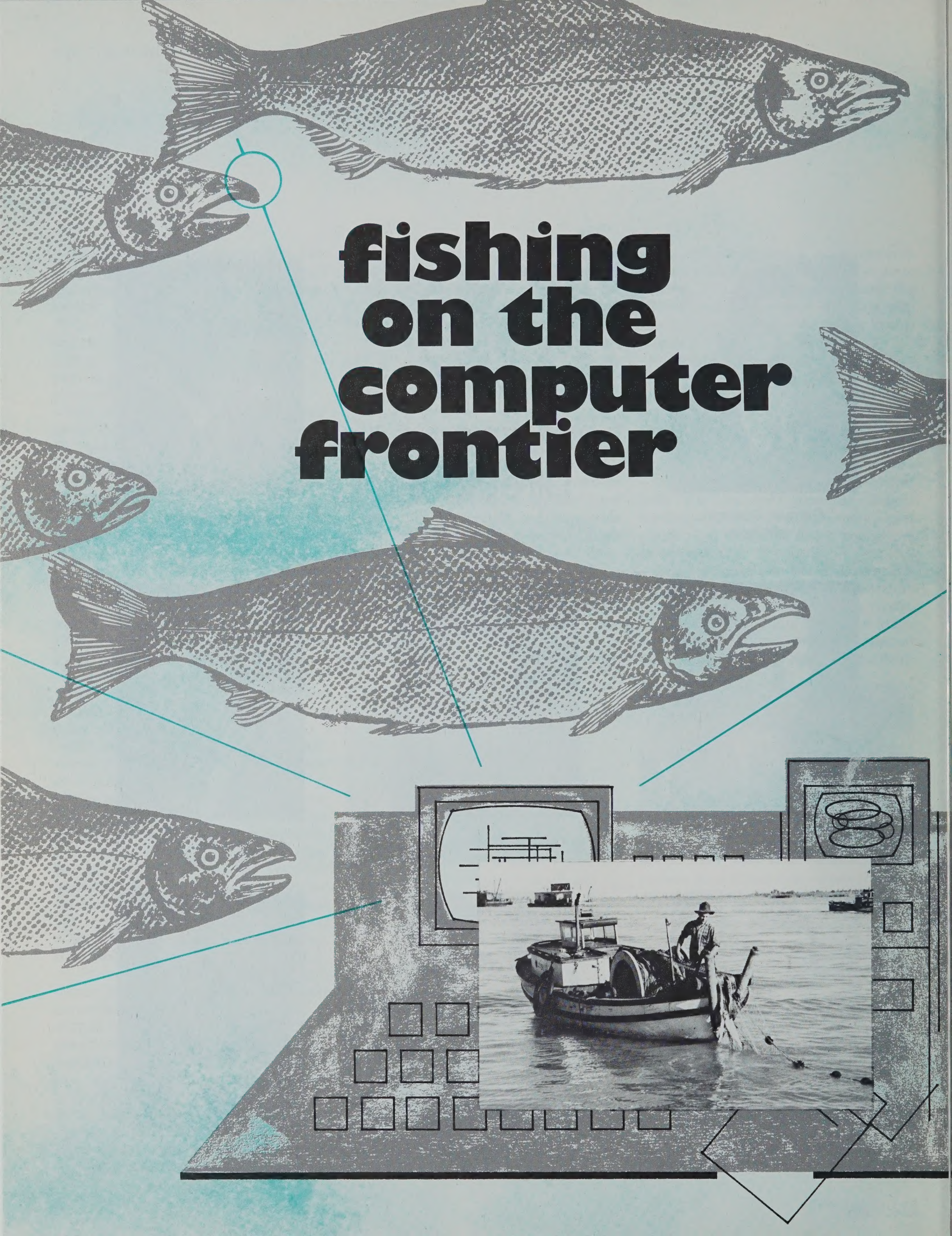
Lewis Branscomb
1969-1973

Richard Roberts
1973-1975



Ernest Ambler
1975-present

fishing on the computer frontier



THE COLUMBIA RIVER MODEL

Fish ladder at Bonneville Dam.

by Emily B. Rudin

SOMEWHERE along the Columbia River in eastern Washington State, an Indian fishes for salmon.

On a tributary in Idaho, sport-fishing enthusiasts examine their catch of salmon after a day's outing.

Hundreds of miles to the west, where the Columbia River empties into the Pacific Ocean, the crew aboard a commercial fishing boat pulls up a net of salmon.

Salmon: here in the Pacific Northwest, they mean a billion-dollar fishing industry, a major recreational resource, and an important centuries-old part of Indian culture. The Columbia River Basin provides one of the primary spawning areas for salmon. So it is not surprising that for over 100 years different fishing groups have competed vigorously with each other for this valuable commodity.

The complex story of salmon is at once political, economic, sociological, and biological. Among its chapters are a major court decision, a breakthrough in biological research, and a series of mathematical models for fishery management designed by the NBS Center for Applied Mathematics. And, like all stories that are not-so-simple, this one is best understood by beginning at the beginning.

A Brief History

For centuries, members of Indian tribes fished for salmon in the Columbia and Snake Rivers, which traverse the interior of the Pacific Northwest. Among the Indians, salmon was a major dietary staple and religious symbol. Historians estimate that in the early 1800's Indians harvested up to 18 million pounds of salmon each year.

But the first half of the 19th century spelled change, with the arrival of thousands of white settlers. In the 1850's, the accommodation of these newcomers was formalized by a treaty that recognized the right of Indians to fish off their reservations—a right, the treaty stated, held "in common with" the settlers in the territory. In theory, the pact was equitable, but in practice it fell far short.

The ever-growing population of pioneers began to compete with the Indians by fishing for salmon along the same rivers. Salmon fishers were at odds with each other, vying for the more favorable fishing sites along the spawning routes. Major conflicts developed between upstream and downstream harvesters.

Ultimately, even though it was unnecessary because of the salmon's migratory route, fishing operations were extended into the ocean itself, oriented out of ports. Even then, however, fishers working from one port were competing with those from another port. Because all the fisheries were linked by the salmon's migration, an increased salmon catch in one place meant a smaller catch somewhere else. The whole network of fisheries was thus affected: offshore commercial and sport fisheries competed not only with each other but also with inland commercial, sport, and Indian fisheries along the Columbia River.

Many factors compounded this intensive pursuit of salmon. For one thing, adult salmon swimming upstream from the ocean to spawn ran a virtual gauntlet of fisheries. As a result, by the time any survivors made it inland to the predominantly Indian fishing areas, the yield was only a fraction of the ancestral harvest.

Then, beginning in 1933, came the dams: first the Rock Island, then the Bonneville, Grand Coulee, and about 20 others, creating many new problems for the salmon. These fish now had to compete for water with two massive new forces—the hydroelectric power industry and its consumers, and the farming communities, which were benefitting from improved irrigation.

Where water had flowed freely, there were now huge lakes backed up by the dams, slowing the fish's downstream migration and making them much more vulnerable to natural predators. Moreover, two of the early dams were not equipped with "fish ladders" through which the migrating salmon could find safe passage, thus cutting off thousands of miles of spawning ground along the Columbia and Snake Rivers. (To date, the U.S. Army Corps of Engineers and other agencies have spent $400 million alone on fish passages and hatcheries to offset the population losses caused by these dams.)

To comprehend the effects of dams on fish, one must squarely confront a central fact: dams put fish in double jeopardy. In the late spring and early summer, when juvenile salmon are traveling downstream, an estimated 10 to 30 percent die at each dam, either as they fall over the spillway or as they pass through the turbines. It is not hard to see, therefore, that the cumulative juvenile mortality

Rudin is a writer and public information specialist in the NBS Public Information Division.

from a journey over five or six dams is very high indeed. Dams again kill salmon when the adults migrate upstream to spawn in early spring. Statistics show a mortality of 5 to 10 percent for adults passing over a dam.

The outlook for salmon—this economic, recreational, and sociological mainstay of the Pacific Northwest—was thus becoming fraught with political sensitivities from every direction. Environmentalists, farmers, power company officials, native Americans, sport fishers, and commercial fishers were ensnared in continual conflict. Life for these people—and particularly for the salmon—was very complex indeed.

In 1978, the Pacific Northwest Regional Commission approached the NBS about developing a mathematical model of the Columbia River Basin. They contacted Frederick C. Johnson, now chief of the Mathematical Analysis Division in the Bureau's Center for Applied Mathematics, and subsequently contracted with NBS to develop the model. Johnson's previous experience with NBS models in Washington State made him a natural candidate for this new project. He had completed a hatchery model in 1974 and a fishery management model in 1976. Under Johnson's direction, the latest model was designed to take into account the best available data on the complex interactions among various components of the problem and provide information to help managers select intelligent alternatives.

Early NBS Models

As mentioned, the hatchery and fishery models devised at NBS before 1978 are the foundation on which the Columbia River model was built.

The hatchery model has two primary capabilities. First, it can perform a complete time-sequenced year-round simulation of the management and biological operations of a hatchery. During this simulation, the model does a benefit/cost analysis; it computes the cost of running the hatchery and the resulting benefits to fisheries. A second function is to determine the best possible economic yield of a hatchery. Linear programming optimization techniques are used to select the particular com-

Brailing pink salmon off the coast of Washington.

Major dams and hatcheries on Columbia River System in Washington State.

bination of species, stocks, size of fish at release, and time of release that generates the most valuable harvest to the fisheries, subject to the constraints of available water flow and water temperature throughout the year.

Although the hatchery model focused on problems in the production of fish, many other problems in the management of fisheries sorely needed attention. The year 1974 brought a stringent interpretation of the original Indian fishing-rights treaties, which stipulated that the Indians' right to harvest salmon was held "in common with" that of the settlers. In what became known as the Boldt decision, U.S. District Court Judge George H. Boldt ruled that the phrase "in common with" meant a precise 50-50 split between Indians and other fishers in the taking of salmon from Puget Sound. That same year Judge Robert Belloni extended the concept of equal harvests to the entire Columbia River. For the Indians, these decisions meant a share much greater than before. Moreover, the rulings implied that there would be no conversion time delay; they were to be enforced right away.

The Washington Department of Fisheries, responsible for carrying out the judges' orders in that State, was concerned about meeting the court-required catch allocation in a truly equitable way. Peter Bergman, its assistant director, contacted Johnson of NBS for assistance.

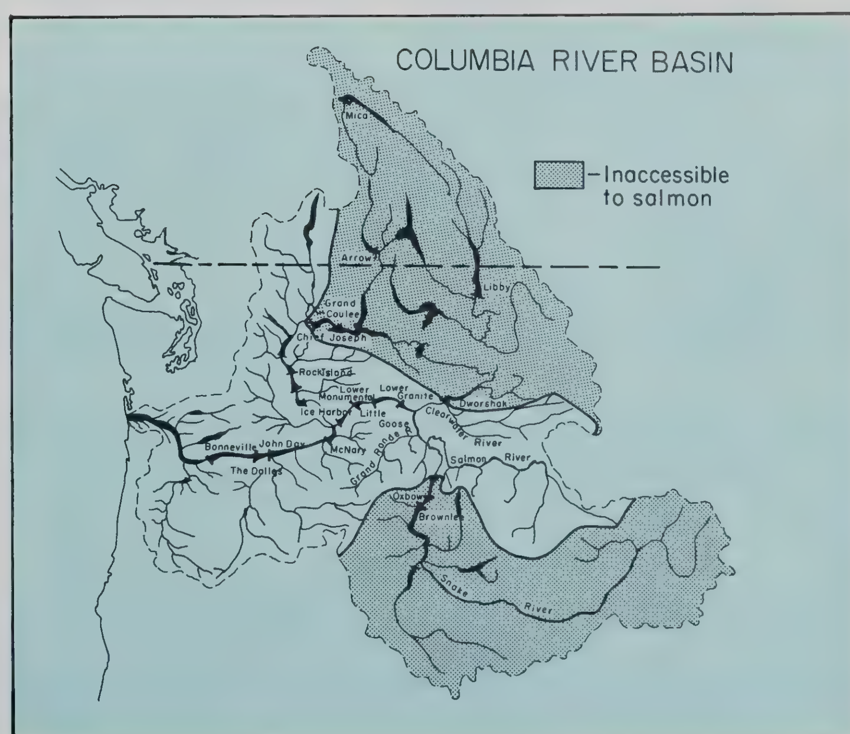
After investigating and assessing the situation, Johnson agreed to begin the project, and the State of Washington contracted with NBS to develop a fishery management model. In July 1974, Johnson moved to Seattle where, for the next three years, he worked closely with management biologists to implement the model and ensure that it was meeting the exact needs of the State Department of Fisheries. "The project couldn't have been developed long-distance," he says. "Nor could it have succeeded without the generous cooperation of the National Marine Fisheries Service, which provided me with office space and support services."

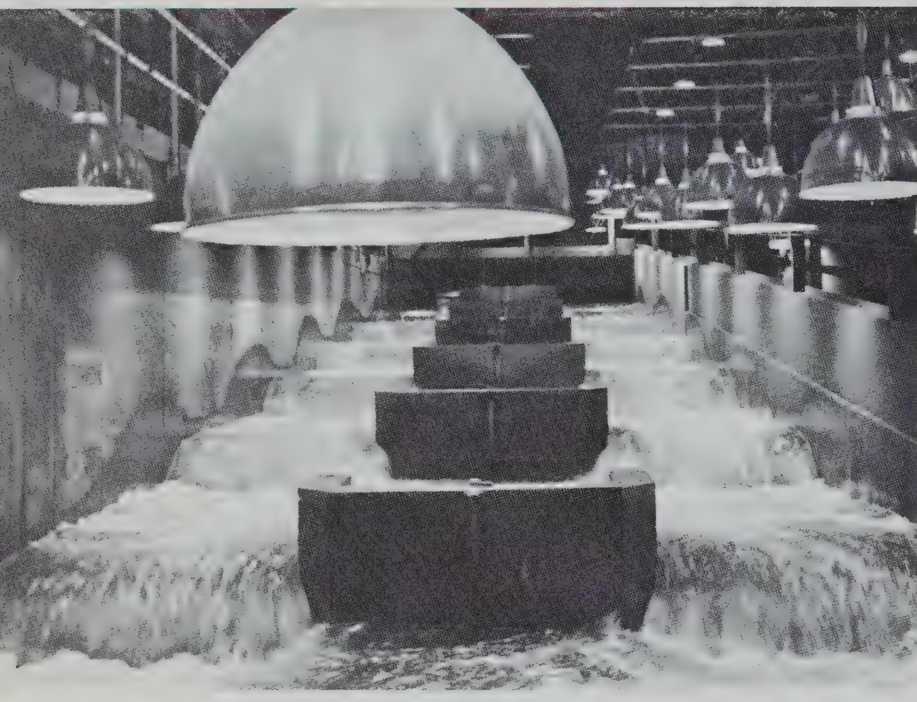
None of the project's components can be studied in isolation, since the salmon's migration route links everything into one big system. "There are hundreds of different runs of salmon," Johnson says, "and each should be managed according to its own needs. Then there is the complex life-cycle of the salmon; a regulation that is effective in spring may not be in summer, so different management measures must be applied from month to month. Finally," he continues, "there is the complex structure of fisheries; regulations and harvesting activities in one fishery have an impact on all others."

The fishery model, with minor modifications since 1976, "has been in the forefront as a fundamental tool for Washington State," according to Johnson. Sam Wright, former head of the Harvest Management Division at the State Department of Fisheries, has acknowledged the model's value by commenting that the Department could not have met the requirements of the Boldt decision without the fishery management model.

The model provides a detailed analysis of the economic and biological effects of changes in salmon fishery regulations. It performs a complete time-sequenced simulation of the salmon's biological processes: growth, natural mortality, migration, and fishing mortality. Economic impacts are measured in the model by changes in the total value of the catch among competing groups of the fishing industry. Biological impacts are measured by determining whether the number of fish returning to spawn is adequate to maintain each salmon stock's long-term stability.

Map shows areas in Columbia River Basin no longer accessible to migrating salmon because of dams.





Laboratory test of a full-scale model of a fishway design.

In addition to being used to assist the Washington Department of Fisheries in dealing with problems resulting from the Boldt decision, the fishery model has also played a role in treaty negotiations between the United States and Canada. Because the migration routes of salmon have no national allegiance, Canadian fishers catch large numbers of salmon produced in American waters, and vice versa.

For several years, the United States and Canada have been conducting formal treaty negotiations to deal with this issue. The treaty's basic goal is to ensure that each country is able to harvest the number of fish that is commensurate with its own natural hatchery production. This is a particularly important concern, since both countries are investing hundreds of millions of dollars in new hatcheries. The fishery model has been used to analyze many of the complex technical issues faced in these negotiations.

The Columbia River Model

The story, then, becomes a very modern one: the role of mathematical modeling as an objective reference point in the resolution of complex natural-resource management issues. The Columbia River model, as it is known, compares alternative ways to invest capital for salmon resource management under various conditions.

How does a mathematical model work to guide the management of fishery resources? "Essentially," Johnson explains, "a mathematical model in this application provides a means for the simultaneous analysis of large amounts of data on the complex interactions among the biological processes, the management decisions, and—ultimately—the economic benefits to the fishing population."

The Columbia River model is a logical expansion of the two previous NBS models and incorporates many of the same variables. It examines the effect of changes in production (both in hatcheries and in the wild); changes in fishing regulations; and changes in the river environment (dams). The model provides a sophisticated tool for analyzing real data and is designed to help resource managers evaluate planning options in production, regulations, and river environment. It can be used to predict who might benefit from various capital investments and how much. Some examples of questions the model is designed to answer:

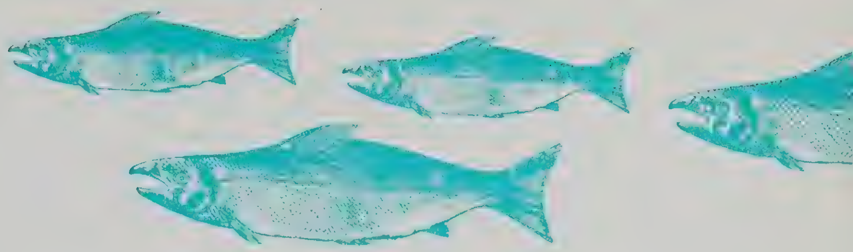
- If a 30 percent mortality rate for juveniles passing over a dam is reduced to 20 percent by manipulating the water flow, what would be the effect, in monetary terms, on a sport fishery 50 miles downstream or on a commercial ocean fishery hundreds of miles away?
- Where should new hatcheries be built relative to dams for maximum production of salmon? (There are no fewer than 70 hatcheries in the Pacific Northwest, with more planned or under construction.)
- If one were to circumvent a dam and transport downriver (by truck or boat) thousands of juvenile salmon from a hatchery, would the increased survival rate be high enough to justify the expense?

The model's strength lies in the fact that it allows resource managers to view the entire system at once—hatcheries, fisheries, dams, and concerns of the various political and economic pressure groups—and to estimate what would happen under different conditions. The key features that the model monitors are the catch distribution (which fishing populations are catching the salmon and what the catches are worth) and the number of adult salmon that escape the network of fisheries and return upstream to the spawning grounds to produce the next generation.

The Columbia River model is nearly complete; data are still being collected and minor modifications added. The State of Washington is preparing the data on approximately 200 different stocks of salmon for a complete analysis of the Columbia River fish-production system. As part of this system, the States of Oregon and Idaho are making major contributions to the data base for this model.

Tagging: A Breakthrough

Johnson emphasizes that the reason this modeling can be done at all is the development of a tagging technique for salmon that, he says, "has



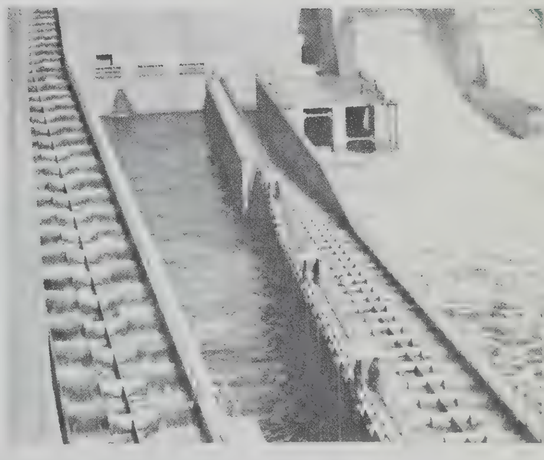
revolutionized the study and management of this fish." In the 1960's, Peter Bergman—then a research biologist at the Washington Department of Fisheries—and physicist Keith Jefferts invented a microscopic coded wire tag that could be injected into the cartilagenous snout of a salmon. Before that time, the only way researchers could mark individual salmon for identification was by cutting various fins, but specimens so marked generally did not exhibit the same behavior as unmarked fish. The behavior of marked fish was biased by altered growth or natural mortality. Thus, by identifying a sample, a researcher might actually be skewing the results.

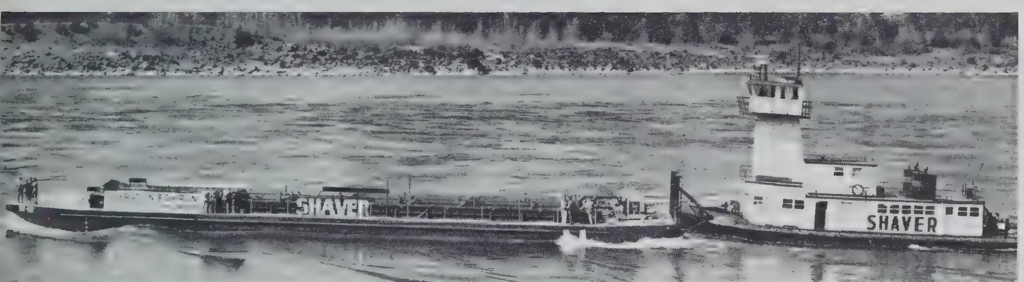
The newer method eliminates the need to clip fins, although the adipose fin—a fatty, nonfunctional appendage along the fish's spine—is still clipped for ready identification of a tagged fish. Millions of salmon are now tagged each year.

When a tagged fish is caught and brought to a State Fisheries representative, its head—of no commercial or culinary value—is cut off, and the code on the wire marker in the snout is read with a microscope. (The rest of the fish is retained by the harvester.) The code provides valuable information about the origin of the fish. This, coupled with catch statistics, ultimately helps answer the question raised by the court mandate: Are management actions adequate to meet the salmon catch distribution on a 50-50 basis for Indians and non-Indians?

To encourage sport fishers to turn in tagged fish heads, Johnson explains with a chuckle, the Washington State Department of Fisheries has hit upon a highly successful incentive program of cash prizes. This program of voluntary compliance for sport fishers, together with the Department's routine sampling of commercial catches, effectively helps ensure representative information that, when analyzed, yields real data for the NBS models. These models, in turn, are providing a basis for intelligent decisions in the equitable management of a precious natural resource—salmon. □

New fishway at Ice Harbor Dam on Columbia River.





Migrating salmon and trout have been boated (top) or trucked (below) around the eight dams on the Snake and lower Columbia River since 1968.

Measuring Through Thick and Thin

Insulation R Values

by Mat Heyman

THERE it is, clearly marked—the R-value. That's what you were told to look for. But what you may not know is that the number on the package is suspect.

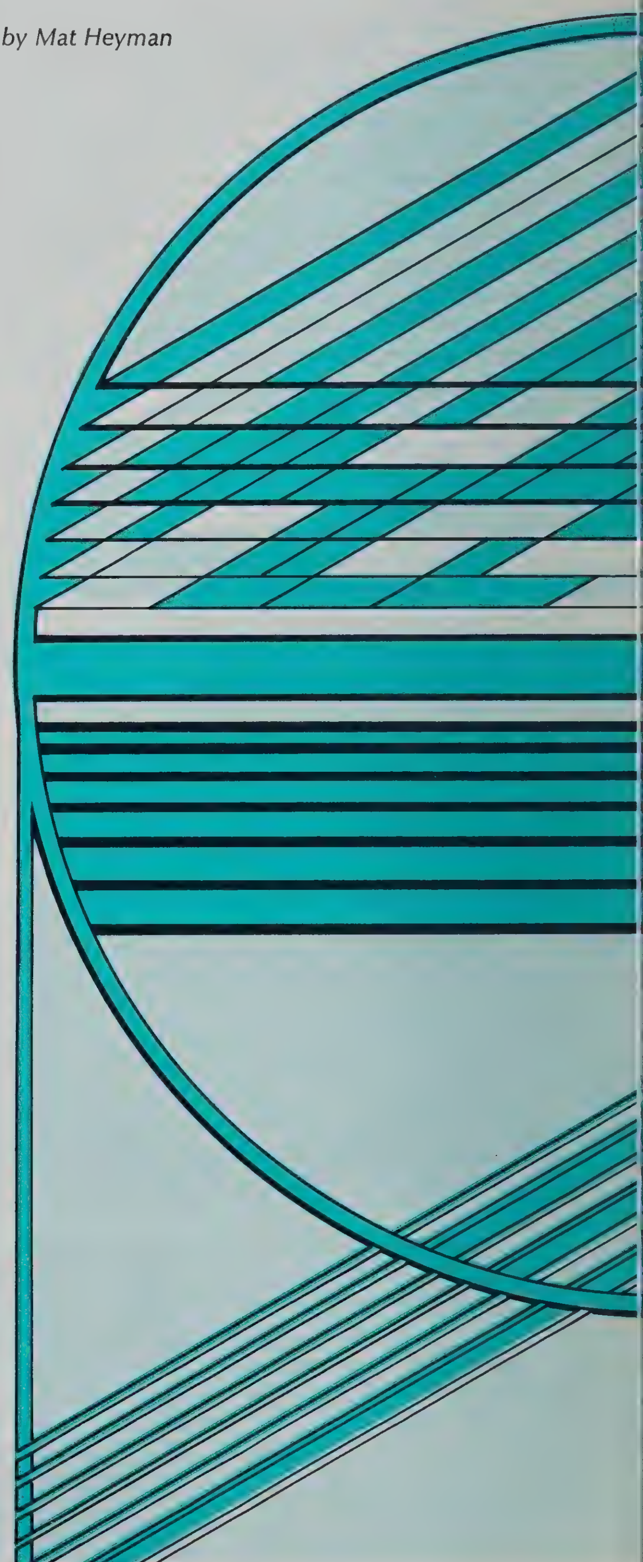
The problem is that determining the exact R-value for insulation is no simple matter, and it is made more difficult because of something known as the "thickness effect." Researchers at the National Bureau of Standards are working on a project that should help eliminate the R-value uncertainty that has been created by this phenomenon.

R-value is short for "thermal resistance." It varies for every batt, blanket, or bag of insulation depending on the material's thickness, density, and other properties. The R-value, along with the kind of installation, determines how effective the insulation is.

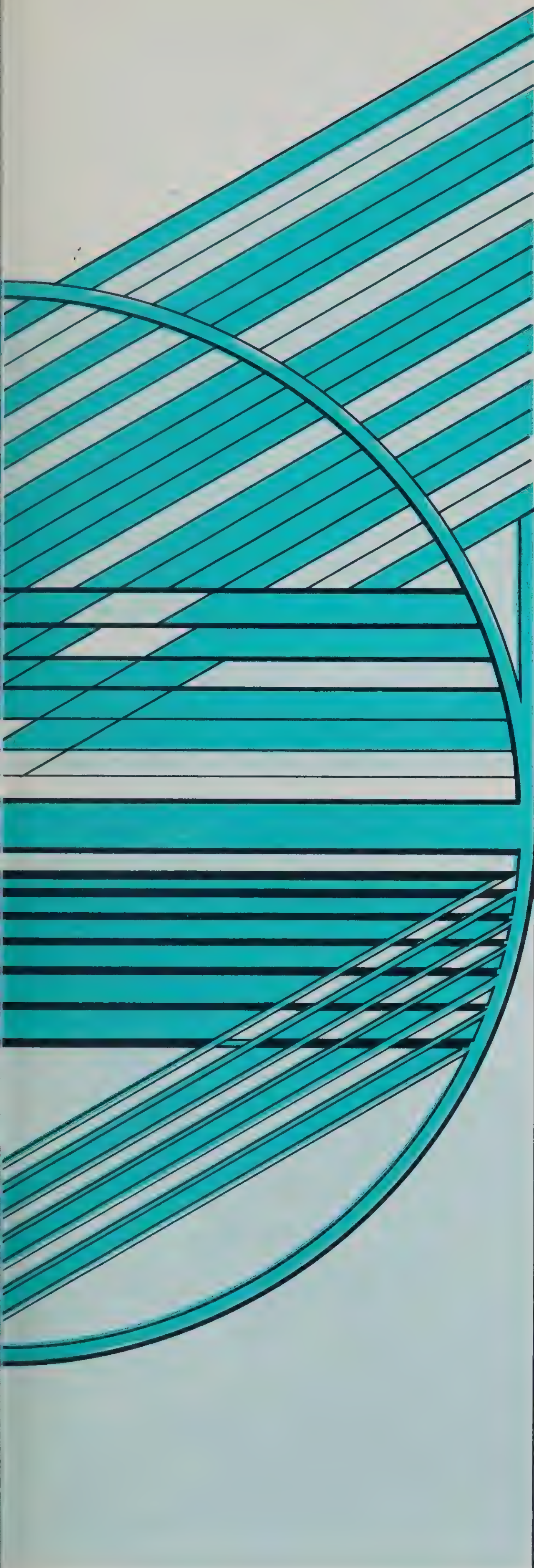
NBS researchers studying the transfer of thermal energy through low-density insulating materials have long believed that R-value does not increase in exact proportion to the increase in insulation thickness. For low-density glass fiber insulation, some researchers believe that the actual R-value can differ from the calculated R-value (which is based on a linear extrapolation from a tested thin sample) anywhere from less than 2 percent to more than 10 percent due to the thickness effect.

But we have lacked the data and equipment needed to answer definitively the questions, "How important is the thickness effect, and how much does it reduce expected R-values?"

There was little interest in quantifying the thickness effect when energy prices were relatively low. For convenience and for lack of research into the phenomenon, the extrapolated value based on thin samples was accepted as satisfactory. But the matter has taken on new importance as Americans have become more energy-conscious and have boosted the amount of insulation in their homes. While an R-value difference of 2 percent or even 10 percent may not be particularly significant in terms of the energy efficiency of an individual home, on a nationwide basis this thickness effect could make a noticeable difference. It is of special concern to the insulation industry, where the amount of material used in the manufacture of the insulation relates directly to the R-value measurement—and represents millions of dollars in production costs.



Heyman is Chief of Media Liaison in the Public Information Division.



The Federal Trade Commission (FTC) came up against the uncertainty due to the thickness effect several years ago when it proposed that insulation packages and advertisements be required to carry information about the material's characteristics and performance. Aside from a desire to ensure that advertised R-values would reflect the actual R-values that consumers would be getting for their dollars, the FTC was interested in making sure that competing firms would make comparable measurements in determining those R-values.

The Commission proposed that insulation manufacturers be required to test their products and provide information about the insulation's R-value based on testing at full or representative thicknesses.* That would solve the apparent problem of having to extrapolate R-values from the 25-mm (1-inch) high-density Standard Reference Material supplied by NBS and used widely to calibrate thermal test apparatuses. The loss in R-value attributable to the thickness effect would thus be taken into account by the actual measurements made by the manufacturer or testing laboratory.

But industry maintained that it was impossible to perform reliable measurements on thick insulation without thick low-density reference samples for calibrating testing equipment. In comments to the FTC, NBS supported that view.

The Bureau had, in fact, already begun work on a test apparatus for thick insulation. With energy prices on the rise, the thermal testing community had become concerned about the inadequacy of their R-value extrapolations based on thin samples, and the American Society for Testing and Materials (ASTM) had called for a national standards laboratory to produce thick insulation transfer standards. Frank Powell, head of the NBS Thermal Insulation Program and the individual responsible for getting the project moving, notes, "Calibrations were being made, but without the low-density insulation used in residences. Industry realized that, and so did we."

Likewise, the Department of Energy had recognized the importance of assuring that homeowners felt confident in the R-value rating of the insulation they were buying. That agency's Buildings Division provided NBS with half the funding needed to design and construct a new test apparatus that could

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** The FTC defines representative thickness as "a thickness at which the R-value per unit will vary no more than ± 2 percent with increases in thickness."*

accommodate insulation at least 300 mm thick. In late 1979, the FTC agreed to defer its requirement for actual or representative thickness testing until the NBS apparatus was completed and calibrated thick insulation samples were available.

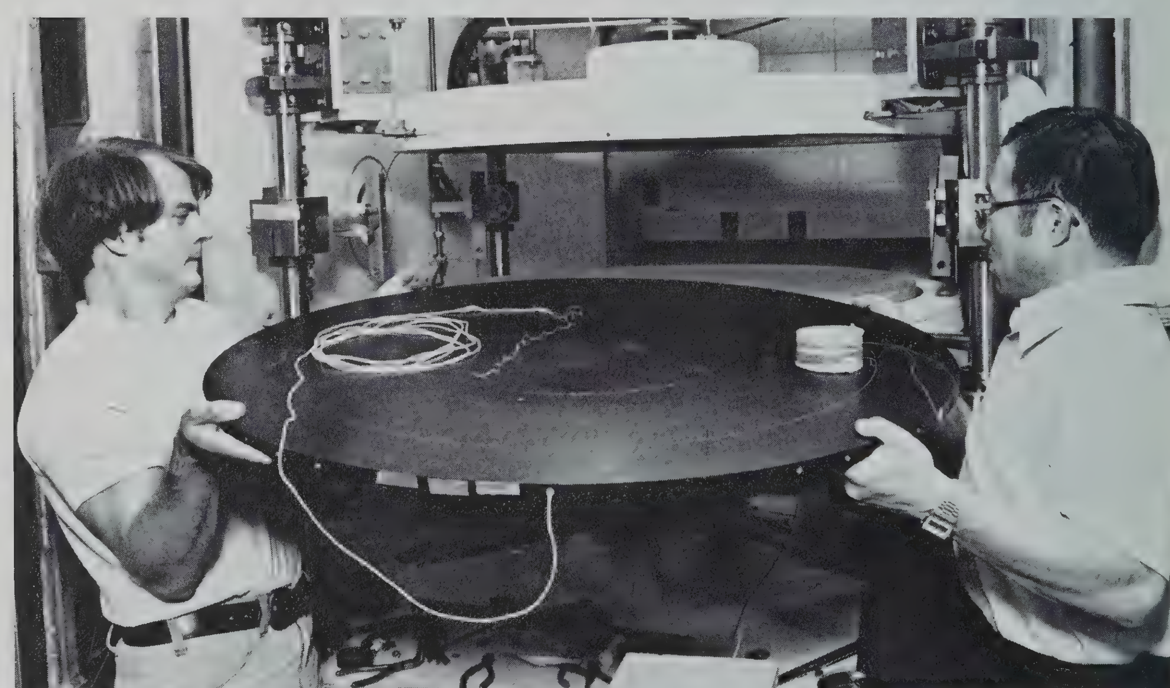
Bigger and Better

A decade ago Mahn Hee Hahn, a mechanical engineer with the Thermal Insulation Group in the NBS Center for Building Technology (CBT), had designed an improved version of the guarded hot plate, one of the conventional instruments used to measure R-value. Hahn had based this prototype apparatus on the concept of a "line source" of heat for the hot plate as opposed to the "distributed heat source" used on many test apparatuses. First suggested in the mid-1960's by Henry Robinson, a long-time NBS researcher and pioneer in thermal measurements, this arrangement made it easier and more reliable to express mathematically the temperature distribution of the device, an important factor in calculating thermal measurements with the apparatus.

While Chock In Siu, an NBS physicist, was establishing that the prototype device was compatible with an older, conventional guarded hot plate used by NBS to turn out the 25-mm Standard Reference Materials, Hahn moved ahead with the design for a bigger and better apparatus—one large enough to measure insulation at its full manufactured thickness.

This "1000-mm circular line heat-source guarded hot plate" operates within its own carefully controlled environment, shielded by an insulated aluminum housing. For the current series of tests, two samples of insulation are placed between a center hot plate (38 °C) and outer "cold plates" (10 °C). The R-value is determined by measuring the power input to the hot plate; the less power required to maintain the hot plate temperature of 38 °C, the better the job that is being done by the insulation in resisting the flow of heat between the plates—and the higher the R-value.

The actual metering area—the section of insulation where heat flow is measured—is 400 mm in diameter. The insulation sample itself is 1000 mm in diameter. The extra width on each side serves as the "thermal guard" to ensure that the effect of heat flow to and from the edges of the insulation sample is minimized in measuring the critical central area. Thus, like its predecessors, this hot plate is "guarded."



The circular "hot plate" being installed by Research Associate Dave Ober (l) and mechanical engineer Mahn Hee Hahn.

Pulling a Team Together

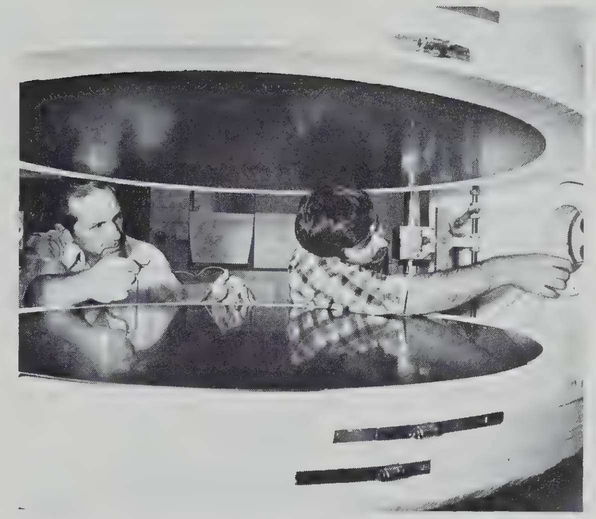
While NBS was proceeding with its design of the 1000-mm apparatus, the Bureau's work took on special urgency because of the FTC's need for standard thick insulation samples to implement its full or representative thickness requirement. To get the guarded hot plate built and into operation quickly, group leader Bob Jones assembled a team of specialists from within CBT and other parts of the Bureau. The Mineral Insulation Manufacturers Association, which has a special interest in the thick insulation samples needed by member companies to improve their measurements, assisted the effort by sponsoring Dave Ober, a Johns-Manville researcher, as an NBS Research Associate for 1 year.*

Much of the unique and high-precision apparatus was fabricated and assembled in the Bureau's instrument shops based on the design of Bill Green and under the guidance of Hahn. Once moved to its present CBT laboratory, assembly of the new guarded hot plate was completed by technicians John McAuley and Rick Petersen and co-op student Mike O'Connell, working under Hahn's direct supervision. Ober provided assistance in the design, procurement, assembly, and debugging of the instrumentation for the temperature measurements.

Calibration of the temperature sensors in the hot and cold plates is a crucial factor in the measurement process. Several staff members of the NBS Temperature and Pressure Measurement and Standards Division were consulted in meeting this need for accuracy. They responded by providing calibration services and some critical instrumentation.

Designing and constructing the apparatus was only part of the job. The selection, preparation, and characterization of insulation materials to be evaluated would be critical to the eventual reliability of the measurements made on the device. Brian Rennex, a physicist in the Thermal Insulation Group, coordinated that task with assistance from Saul Baker and student researchers Dave Uhrenholdt and Sally Pfeiffer.

No matter which low-density glass fiber specimens would be used as calibration samples, these materials would be intrinsically variable across the



Technicians John McAuley (l) and Rick Petersen instrument the new 1000-mm guarded hot plate. The apparatus will permit more reliable measurements of thick insulation's R-value.

width and thickness of the specimen. According to Rennex, "Even when the specimen is actually measured on the NBS apparatus, this variability presents a potential problem in transferring measurements to another apparatus." To help reduce this variability 1200-mm batts of low density glass fiber insulation were photographed on a light table. Next, more uniform 600-mm square sections were visually selected from the larger sheets.

Then, the CBT team determined the average densities corresponding to the NBS and user apparatuses, adjusting the calibration factors accordingly. This step offers a way to significantly reduce the uncertainty of the calibration.

Rennex and Hahn are now working on models to account for errors due to material variability and test apparatus design and instrumentation, including measurement of the heat flow and average plate temperatures, distance between plates, metering area, and effect of heat losses at the sample's edges.

First Thick Samples

This teamwork is paying off in the form of the first calibrated thick insulation transfer specimens. Ten manufacturers and commercial laboratories will receive simultaneously the initial batch of transfer specimens provided at thicknesses of 25, 75, and 150 mm (1, 3, and 6 inches). The samples will permit these customers to calibrate their own guarded hot plates and heat flow meters and ensure

**The NBS Research Associate Program enables technical specialists in U.S. firms and professional organizations to work at NBS temporarily in order to carry out projects of mutual interest.*

that more reliable R-value measurements will be made on the insulation that eventually ends up in the walls and attics of America.

Future Research

Group leader Bob Jones says, "Our first goal has been to supply calibrated transfer specimens. Next we will extend the capability of the apparatus so that it can handle even more sensitive measurement tasks and help us to improve our understanding of the thermal transfer properties of insulation." Also, NBS will complete a series of tests on the Bureau's 200-mm and 300-mm guarded hot plates and the heat flow meter to establish the correlation of measurements made on these test apparatuses. This research will be used to validate a heat transfer model that can predict the thermal performance of entire insulation systems as a function of material specifications.

Jones and his team soon will be altering the apparatus to operate at temperatures up to 150 °C and down to −40 °C. This will permit use of the hot plate at varying temperature ranges to reflect the different conditions under which the insulation might be used. Moreover, the apparatus is designed to be rotated 90 degrees to achieve horizontal heat flow, an arrangement that would better simulate low density insulation as it is installed in walls. By testing insulation under this condition, NBS researchers will be able to learn more about the possible effects of convection within insulation—something that needs to be defined.

While the measurements NBS is making on thick insulation will undoubtedly help to quantify the thickness effect in insulation, it will take repeated tests before the effect of this phenomenon on insulation's R-value can be defined with any certainty.

Says Jones, "The thickness effect is a well-accepted premise by now. But even if we can quantify it, there still will be considerable discussion about its cause. Is it due to radiative heat transfer? Convection within the material? Or something else? We just don't know for certain." Those are some of the questions that NBS will be trying to answer as the new hot plate is put to work. □

NBS researchers are producing carefully characterized samples of thick insulation. Here, group leader Bob Jones (r) and physicist Brian Rennex examine potential samples using a light table. The insulation's varying density presents a problem in preparing samples.

CALIBRATING THE FFTF

by Michael Baum

Arranged towards the back of David Gilliam's desk at the NBS Center for Radiation Research are two empty, green Chianti bottles, veterans of the traditional christening ceremony for new nuclear reactors and mementos of the more than 4 years of work put in by Gilliam and his colleagues to ensure that the country's new high-powered fuels test reactor will deliver good, accurate information.

The reactor is the Fast Flux Test Facility (FFTF), located in Washington State and managed by the Westinghouse Hanford Company. The FFTF is now the center of U.S. research on breeder reactors, according to Gilliam, a nuclear engineer who acts as project leader for the NBS contribution to the program. If the United States decides to go ahead with the commercial development of breeder reactors, the FFTF will facilitate their design on a sound groundwork of theory and data.

The FFTF will be used to test different fuels for new reactors, an important issue since the behavior of the fuel depends on how it is burned in the reactor. "Since it is a test reactor," explains Gilliam, "and the whole purpose is to subject fuel to neutron bombardment and intense energy generation rates, it is critical to know what the actual conditions in the reactor will be."

The NBS role was, in a sense, to calibrate the new reactor by determining power levels and rates at which fission (splitting of an atom's nucleus) reactions take place within the reactor.

The first task, shortly after the FFTF was started, was to calibrate accurately the ascent of the reactor to its full power level of 400 megawatts, assuring, among other things, that safety devices were properly set. The calibration was based on the measured fission rate (fissions per second per gram of fissionable material) in a sample of plutonium-239 amounting to less than 2 micrograms.

Fission rates will be measured routinely during fuel tests by placing carefully measured, minute samples of radioactive isotopes within the reactor core, and then removing the samples after a time to measure the amount of reaction products present. (This is called a fission product activation method, and is considered a passive test.) Fission rates for each isotope vary from reactor to reactor, depending on factors such as geometry, construction materials, and power levels, and are one of the most important parameters to know in a power or research reactor.

For this reason, NBS participated in a second, more complex experiment to measure directly the fission rates for eight fissionable isotopes to be used in the fission product activation method. All of the isotopes were referenced to isotope-mass standards at NBS.

The experiment, notes Gilliam, was in preparation for 4 years and executed in just 60 hours. Intense and often redundant preparations were necessary to assure accurate, absolute measurements under the unforgiving conditions of a one-shot experiment.

Working with samples ranging in mass from 0.7 milligram to as small as 0.1 microgram, the researchers conducted a series of mass assays of samples of plutonium-239, -240, and -241; uranium-233, -234, and -238; thorium-232; and neptunium-237. The selection covers almost all of the important isotopes found in the fuel cycles for advanced power reactor options. The analysis involved work by several NBS groups, including alpha emission rates certified by the Center for Radiation Research, relative thermal fission counts made in cooperation with the NBS Reactor staff, and isotope-dilution mass spectrometry performed by the Center for Analytical Chemistry.

The broad range of isotopes used in the experiment gives an added benefit, according to Gilliam. Because each isotope begins to fission efficiently at different neutron energy levels (called threshold energies), comparison of the observed fission rates of the eight isotopes with their known threshold energies yields a useful profile of the neutron energy distribution within the reactor.

In addition to the analysis of the isotope samples, NBS researchers worked on a set of design alterations of the fission chambers that were used to obtain a direct reading on the isotope fission rates in the reactor core (and so calibrate the passive measurement method).

A fission ionization chamber detects the nuclear fragments from fissioning atoms as they pass through argon gas contained in a small chamber, creating a brief electrical pulse. These delicate devices, originally designed for laboratory use, were hardened for use in the harsh and remote environment of a sodium-cooled power reactor by engineers from Westinghouse-Hanford working in close collaboration with NBS scientists.

The result was an engineering first. Never before has an absolute fission rate detector been operated in the hostile surroundings of a commercial-scale reactor with the same precision as achieved in the laboratory.

Baum is a writer and public information specialist in the NBS Public Information Division.

PLANNING FOR FUTURE SRM'S

by Stanley Rasberry

Standard Reference Materials (SRM's) have been produced, certified, and issued by NBS since 1906. These materials, with specific chemical or physical properties certified by NBS, have found wide acceptance especially by industrial users needing to maintain or increase high levels of productivity. Today, 84 of the 100 largest manufacturers in the United States, together with about 10 000 other users, buy over 40 000 SRM units per year to the tune of about $3.0 million.

The SRM's have a vital role in promoting industrial productivity by helping to maintain:

- Reliability and uniformity of materials in meeting specifications.
- Quality control in raw materials and produced goods or services.
- Interchangeability of materials and subcomponents.

In addition to the industrial customers, major SRM users include Federal and State Governments, universities, and non-profit research establishments, particularly for use in the areas of health, environmental protection, metrology, and forensic science. International distribution of SRM's accounts for about 20 percent of the total.

In the last 14 years, the NBS-SRM Program has greatly expanded the nature and scope of its activities. In 1966, NBS offered for sale 55 different SRM's, which were intended to serve the measurement needs of rather limited but important segments of the U.S. economy. At that time, the SRM inventory consisted mostly of metal-bearing ores, metals and alloys, cement, glass, and inorganic chemicals.

By 1980, the participation of 23 NBS technical divisions added strength to the SRM Program and enabled NBS to increase the number of SRM's to about 1000, including many new areas such as computer technology, fire safety, forensic science, and radio-pharmaceuticals, with recent emphasis particularly on environmental and clinical measurements. The expansion of the SRM Program was accompanied by a corresponding widening of the customer base. In the period 1969-1980, SRM sales more than doubled, dollar-wise.

The scope of our future plans for SRM production is indicated in the table. From our perspective, the following are the four most important considerations, or as we call them, "external trends," affecting future SRM production.

- *Increased Importance of Measurement Compatibility in Technological World.*

During the next decade, international SRM activities are expected to increase dramatically, including the joint development of multi-national reference materials to meet international standards. Great care must be taken to assure that international standards, which require the use of reference materials, foster international trade rather than serve as a barrier.

- *Increased Cost of Raw/Processed Materials and Energy.*

Recent increases in the cost of raw and processed materials, as well as the cost of energy, have resulted in the development of more stringent procurement specifications for materials sold in national and international commerce. SRM's are being used more and more to provide a basis for the arbitration of disputes between producers and users of materials, as well as in the traditional role as part of production quality control systems.

- *Increased Development of New Materials in High Performance Applications.*

The development and use of materials for high-performance applications has grown considerably in recent years. This trend is leading to the development of a wide variety of new high-performance materials serving many diverse uses. Many of these materials are used in critical applications where their failure in service could result in serious safety hazards. Examples range from high-temperature corrosion-resistant alloys used in aircraft turbine blades to plastic foams used in building construction.

- *Increased Development and Implementation of Government Imposed Health and Safety Regulations.*

The NBS response to this trend has been the establishment of a number of programs aimed in part at providing a reliable measurement base for regulatory agencies. These include the Environmental Measurements Program, Nondestructive Evaluation Program, Resource Recovery Program, Recycled Oil Program, and the Nuclear Safeguards Program. A program for Measurements and Standards for Nuclear Waste Management has also been recently proposed. All of these programs will require the development of new SRM's to serve as measurement technology transfer mechanisms.

Projected Demand for NBS-SRM's
Fiscal Years 1982-86

SRM Category	Inventory 4/30/80	SRM Renewals* 1982-86	New SRM's 1982-86	Current SRM's to be Discont'd. 1982-86	Inventory Projected 1986
Metals	316	53	80	108	288
Nonmetals/Glass	74	15	30	10	94
Chemicals/Rubber/Plastics	105	23	24	32	97
Nuclear	30	10	20	0	50
Radioactivity	156	71	20	38	138
Engineering	146	146	46	58	134
Environmental Gases	54	145	25	10	69
Environmental Liquids/Solids	35	21	30	6	59
Health	42	33	25	6	61
Science/Metrology	105	20	10	48	67
Total	1063	537	310	316	1057

* Includes a number of multiple renewals in the radioactivity, engineering, environmental gases, and health categories.

Rasberry is Deputy Chief of the Office of Standard Reference Materials.

STAFF REPORTS

NBS DEVELOPS NEW CLOCK SYNCHRONIZATION TECHNIQUE

Tracking and controlling deep space probes such as Voyager I and II require a technique of radio-astronomy called long-baseline interferometry (LBI). LBI, in turn, requires that the widely separated clocks of the tracking station network run at the same rate to within 30 nanoseconds per day to achieve the needed accuracy of range, direction, and speed measurement. NBS is developing a system for this rate control that will be far less expensive than current methods and will not tie up the large tracking station antennas as at present.

David Allan, Time and Frequency Division, Room 4035 Radio Building, Boulder, CO; 303/497-5637.

The extraordinary detail and quality of photographs and other data returned from the Voyager I and II missions to Jupiter and Saturn have overshadowed an equally impressive achievement in deep space tracking and guidance.

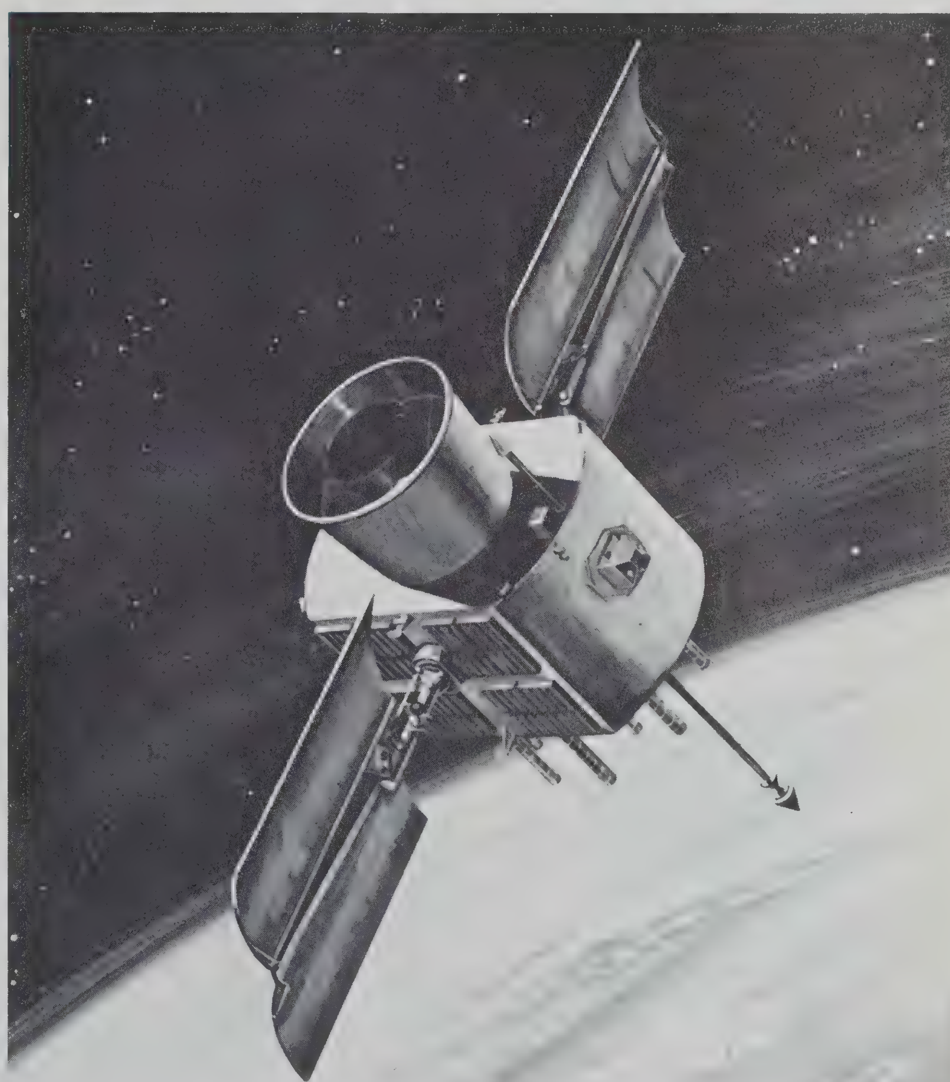
The close approaches to Jupiter and its satellites, the subsequent "crack-the-whip" maneuver which used Jupiter's gravity and orbital energy to send both craft on their way toward Saturn, and the final similar maneuver around Saturn to send Voyager I towards Uranus, all depended crucially on precise control and knowledge of the vehicles' direction, range, and speed. And this speed and distance information had to be obtained from a distance of over a billion kilometers.

The three tracking and control stations on Earth that accomplish this precise, very-remote control are located in California, Australia, and Spain. They form the NASA-JPL (Jet Propulsion Laboratory) Deep Space Network (DSN). Each station has a huge dish antenna 64 meters across, instruments to detect and record the faint radio signals from the spacecraft, and a very precise time and frequency generating system or clock.

When the clocks of any two stations are accurately running at the same rate and the two stations can both "see" the space probe, the stations can use long-baseline interferometry to determine the probe's direction in space very accurately. Since the stations are separated by almost one Earth diameter, they can also determine the distance to the probe by triangulation. And finally, by measuring the Doppler shift of the frequency of the signal from the probe, they can deduce its speed.

One of the big problems faced by the DSN has been to keep the clocks running at the same rate. This has been done by simultaneous observations of certain radio-emitting stars or other sources, but the process requires several hours of use of the main dish antennas at each station. It is estimated that this process costs over $100 thousand per calibration, and during the time it is being used for this, the antenna cannot be used for any other purpose.

Recently, the National Bureau of Stand-



Type of satellite used for clock-rate control.

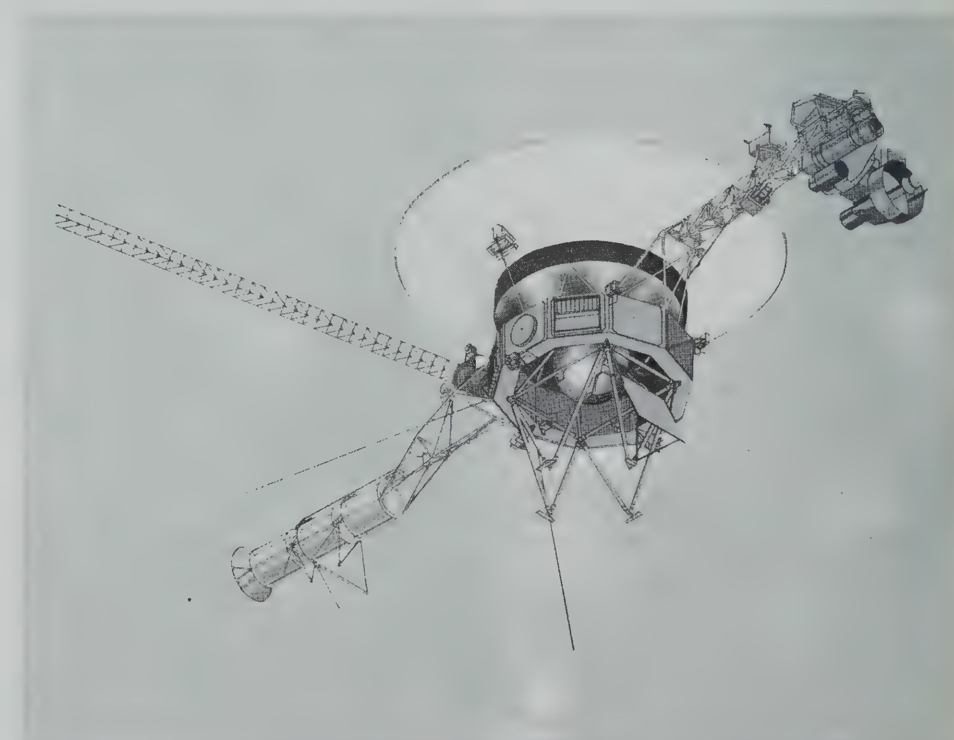
ards' Time and Frequency Division proposed a better and far cheaper method of setting the rates of the DSN clocks. NBS has now received a contract from JPL to develop the proposed system and refine the technique. Delivery of prototype equipment to JPL is scheduled in or before February 1982, but both parties are working toward earlier delivery, perhaps in time for the Voyager II encounter with Saturn next August.

The NBS concept is to use signals from an Earth-orbit satellite system, called the Global Positioning System (GPS), to calibrate the rate of the California clock against the rate of the NBS primary standard by simultaneously receiving the signals at both locations from the same satellite. The other DSN stations would then be calibrated against the California station by using the same approach. GPS satellites are designed to provide super-accurate navigation signals for ships and planes and can be received easily with small antennas. (Eventually there will be 18 of these satellites in orbit, so that at least four will be visible from anywhere on earth at the same time, but there are only six orbiting at the moment.) Thus, the large DSN antennas will not be tied up in the clock rate-setting process. The GPS-based synchronization scheme will provide the needed rate-setting accuracy of 30 nanoseconds per day (about 3 parts in 10^{13}).

NBS will also be studying the possible use of sequential viewing, in addition to simultaneous viewing, of GPS satellites. This would permit, say, the California DSN station to set its clock according to a satellite as it passes over, then later, as the same satellite passes over Australia, the Australian DSN station would make a similar adjustment. The questions to be settled are: can the errors due to different satellite altitudes, ionospheric conditions, and the like be determined and removed? And, are the satellite signals sufficiently stable over a period of several hours to permit such use? Preliminary studies indicate the answer to each of these questions is affirmative, to the degree of accuracy needed.

These proposed methods of clock synchronization are not limited to space tracking networks. They can also be applied to other situations where two or more clocks must be synchronized to about 10 billionths of a second. These methods will be much cheaper than transporting portable atomic clocks from place to place, a method used in the past to check the DSN.

The system NBS is developing will consist of GPS time-code receivers, antennas and their controllers, and data input and output devices. The receivers include circuitry to correct the satellite signals for various known errors and then to compare them with the tracking station time signal. When two stations carry out this comparison simultaneously (or sequentially), each station can then determine its relation to the other and, if necessary, synchronize its clock.



The bowl-shaped antenna carried atop the Voyager I is about 3.6 m (12 ft) in diameter.

PROGRAM AIDS CRITICAL EVALUATION OF SINGLE-CRYSTAL AND POWDER DATA

*An efficient cooperation between the NBS Crystal Data Center and the International Centre for Diffraction Data (JCPDS) has resulted in the completion of Version I of a computer program, NBS*AIDS80. It is now ready for distribution to data base builders, to research scientists, and to journal editors.*

J. K. Stalick, A. D. Mighell, and C. R. Hubbard, NBS Crystal Data Center, B220 Materials Building, 301/921-2950.

NBS*AIDS80 is a sophisticated computer program that makes common procedures possible for data base building, for the critical evaluation of crystallographic data, and for product generation. The program is written in FORTRAN, is modular in design, and contains many evaluation subroutines.

The program derives from several years of experience in the computer-assisted evaluation of crystallographic data at the National Bureau of Standards. It is used routinely by the NBS Crystal Data Center for the analysis of crystallographic data in the preparation of the NBS Crystal Data File and by the JCPDS for the analysis of powder data for the Powder Diffraction File. As there is a very close relationship between single-crystal and powder data, the combined evaluation of single-crystal and powder data in a common format enhances the quality of data in both compilations. For example, the program permits the indexing of input powder data. Once the pattern has been indexed, the program compares the observed and calculated d-spacings, flags systematic absences if present, and calculates figures of merit. If the figures of merit are high, both the crystal cell dimensions and the powder pattern have a high probability of being correct.

NBS*AIDS80 was originally intended for use by the data base builders in the evaluation and transformation of literature data and in the creation of master data files. Such files facilitate research studies, generation of indexes, and preparation of publications. In the evaluation of thousands of entries for the Crystal Data and Powder Diffraction Files, an unexpectedly large number of errors in the published crystallographic data have been found, especially with regard to symmetry determination, unit cell transformation, density calculation, and the indexing of powder data. By using NBS*AIDS80, research scientists and journal editors can find and correct such errors prior to publication. Additional analysis routines are being developed for incorporation into the program.

In addition, the program has many other research and analysis applications. It may be used in conjunction with routine diffractometry for identification and characterization of materials. For example, once unit-cell dimensions for a crystalline compound have been determined, the program can establish the probable symmetry of the lattice, the transformation matrix to the standard setting of the cell and space group, the calculated density for a check on the unit cell contents, and the reduced cell needed to determine if the same or an isostructural compound has been previously reported in the literature.

The determination of a crystal structure is expensive, typically costing several thousand dollars. Unfortunately, it is not uncommon for the same structure determination inadvertently to be carried out more than once; use of NBS*AIDS80 can help prevent this type of error.

The program evolved through invaluable contributions to the design and development by the following: R. J. Boreni of the NBS Crystal Data Center, L. Calvert of the Metals Data Center (Ottawa, Canada), E. Evans of the JCPDS research associateship at NBS, M. Holmany and F. McClune of the JCPDS, J. R. Rodgers and D. Watson of the Cambridge Crystallographic Data Centre, A. Santoro of the NBS Reactor Division, and R. Snyder of Alfred University. Work on the program was sponsored by the NBS Office of Standard Reference Data; the NBS Ceramics, Glass, and Solid State Science Division; and the JCPDS.

COOLING ATOMIC IONS WITH LASERS

A new technique for isolating and cooling charged particles is being refined to improve the stability of frequency standards and the resolution of laser spectroscopy by reducing Doppler shifts and perturbing influences on the particles. For example, the second order Doppler effect can be reduced by more than three orders of magnitude using the electromagnetic trap and laser cooling of ions.

James C. Bergquist, R. E. Drullinger, Wayne M. Itano, F. L. Walls, and David J. Wineland, Time and Frequency Division, 2031 Radio Building, Boulder, CO 80303, 303/497-5286.

One of the biggest obstacles to improving the resolution of laser spectroscopy and the precision of atomic clocks and frequency standards is the problem of Doppler broadening and shifting of atomic and molecular resonances. No matter how stable the interrogating frequency, if the particles being studied are in motion along the direction of interrogation, the response will, in general, be broadened and shifted. One way to reduce these Doppler effects is to cool the particles under study to temperatures near absolute zero.

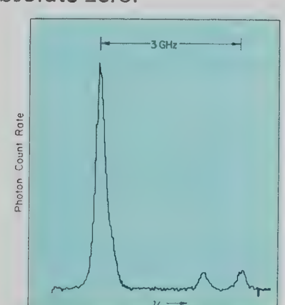
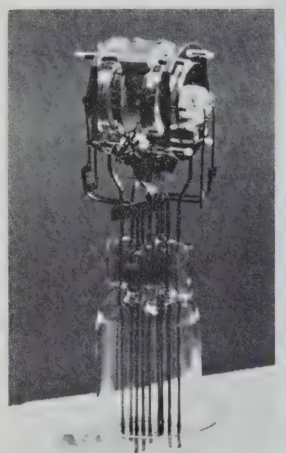


Figure 1—*Spectra of one Zeeman component of laser cooled $^{24,25,26}Mg^+$. The room temperature Doppler width of these lines is about 3 GHz. Only the $^{24}Mg^+$ is directly cooled; the others are cooled by coulomb interactions with ^{24}Mg.*



The electromagnetic trap used to isolate the ions for cooling.

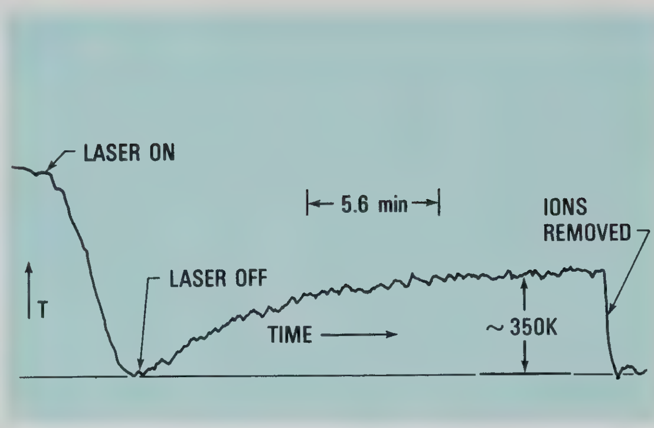


Figure 2—*Ion temperature T vs time when laser cooling is applied. The initial temperature was elevated by heating the ions with the laser at a different frequency; 350 K is approximately ambient temperature. Only about 8 microwatts of power were used in the cooling beam, with the frequency set about 2 GHz below the ion's resonant frequency.*

Ordinary cooling methods are usually unsuitable because the particles must be prevented from touching any foreign material, such as a cold wall or cold gas. Collisions with surfaces or foreign particles would introduce perturbations which might be at least as disruptive as the Doppler effects themselves, or would remove the particles being studied from the system by adsorption or by neutralization of charge.

In the NBS Frequency and Time Standards group, an approach to this problem has been to isolate the particles from perturbing influences by suspending them in an electromagnetic "trap" and then lowering their temperature. The theory of how radiation can *lower* the temperature of an object can be explained in several different ways; here we shall use one of the simplest concepts to explain the main aspects of the cooling.

When an atom is moving toward a source of radiation (a laser, for example) of frequency f, the frequency it experiences is Doppler-shifted upward to f + Δf, where Δf is usually a small fraction of f depending on the velocity of approach. If we choose f so that f + Δf exactly matches one of the atom's natural resonances, the atom will absorb a photon with energy *hf* (*h* is Planck's constant). Later, that atom will re-emit a photon at, on the average, its natural resonance frequency f + Δf, thus carrying off energy *h*(f + Δf). The net loss of energy *h*Δf in the overall process results in a slower atom (i.e., it moves more slowly than before along the axis of the laser beam). Each scattering event typically lowers the temperature of an atom a hundredth of a degree or less, so each atom has to absorb and re-emit thousands of photons to lower its temperature appreciably. Luckily, even low-intensity lasers can provide the needed photon fluxes so that cooling from 300 K to less than 0.1 K occurs in a matter of seconds. Also, the laser beam can be reflected back through the trap so that particles moving along the beam in both directions can be cooled.

If the atoms (or other particles) were completely free to move in space, the scheme outlined above would cool only the velocity components anti-parallel to the axis of the laser beam. But by confining them electromagnetically and directing the laser at a certain angle to the confining field, we can cool all components of motion. Also, if ions or other charged particles are used, electrostatic forces among them will make the cooling along one axis effective along the others as well.

The electromagnetic trap is a device that creates an electromagnetic field of a certain configuration to hold particles within a small defined region. The working volume is only a fraction of a cubic centimeter, but large enough to hold thousands of ions, if desired.

In addition, the same apparatus can be used to isolate one single particle for study. The fluorescence spectrum from a single magnesium ion ($^{24}Mg^+$) has been observed using these techniques. The procedure is to load several ions into the trap, cool them with the laser to less than 1 K, and use the light pressure to compress the ion cloud so that the ions are centered and contained within a volume no greater than about 1,000 cubic micrometers. The fluorescence of the ions is monitored continuously while atoms of the ^{25}Mg isotope are directed at them to remove them from the trap one at a time by charge exchange. The fluorescence signal decreases in steps as the ions are removed, until only one is left. This one ion can be studied for its own properties, since the single ion has no frequency shifts due to neighboring ions, or it can be used to examine the laser cooling process itself. For a single ion, an exact theoretical solution is possible, which can be compared to experimental results.

The ability to deal with particles in a relatively undisturbed state, while removing almost all first- and second-order Doppler shifts, provides the spectroscopist with an extraordinarily useful tool for his work and could lead to a significant improvement in ultra-high-resolution spectroscopy. For the Time and Frequency Division, having access to undisturbed atoms at extremely low temperatures means, among other things, having the possibility to develop time and frequency standards up to a hundred times better than at present.

CONFERENCES

For general information on NBS conferences, contact JoAnn Lorden, NBS Public Information Division, Washington, DC 20234, 301/921-2721.

NATIONAL WATER CONSERVATION CONFERENCE

The 1981 National Water Conservation Conference on Publicly Supplied Potable Water Systems will be held April 14-15 at the Denver Hilton Hotel, Denver, Colorado.

Sponsored by six U.S. Federal Government agencies (the Environmental Protection Agency; National Bureau of Standards; Office of Water Research and Technology, Department of the Interior; Army Corps of Engineers; Department of Housing and Urban Development; and Water Resources Council), the conference will examine the interaction of local and State water management groups with Federal programs that provide assistance and incentives for potable water conservation and related wastewater flow reduction.

Workshops will be held on economics, technology, education, planning, water law and allocation, manuals, and state-of-the-art demonstrations of conservation equipment.

The conference is designed for industry representatives such as manufacturers, engineers, builders, and plumbers, as well as for local, State, and Federal officials of public service commissions, water resources boards, and organizations concerned with conservation, research and development, and management.

Featured in the forum-like format will be information exchanges on day-to-day experiences with implementing local water conservation programs and on supply-versus-demand management. Attendees will also focus on establishing a rationale for water conservation and the public benefits obtained in terms of economics, environment, land use, and resource use.

For further information, call Gail Cioban or Sheri Marshall at 301/468-2500. Registration is being coordinated by Enviro Control, Inc., P.O. Box 827, Rockville, MD 20851.

CONFERENCE CALENDAR

April 6-10
6TH INTERNATIONAL SYMPOSIUM ON NOISE IN PHYSICAL SYSTEMS, NBS, Gaithersburg, MD; sponsored by NBS and the Catholic University of America; contact: Robert J. Soulen, B128 Physics Building, 301/921-2018.

April 14-15
NATIONAL WATER CONSERVATION CONFERENCE, Denver, CO; sponsored by NBS, EPA, DOI, HUD, and WRC; contact: Lawrence Galowin, B306 Building Research, 301/921-3293.

April 21-24
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry Burnett, B266 Materials Building, 301/921-2992.

April 30-May 1
NATIONAL ROOFING TECHNOLOGY CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and NRCA; contact: Robert Mathey, B348 Building Research, 301/921-2629.

May 28
TRENDS AND APPLICATIONS, NBS, Gaithersburg, MD; sponsored by NBS and IEEE; contact: Elizabeth Parker, A209 Administration Building, 301/921-2629.

June 1-3
6TH INTERNATIONAL SYMPOSIUM ON IMAGING AND ULTRASONIC TISSUE CHARACTERISTICS, NBS, Gaithersburg, MD; sponsored by NBS, NIH, IEEE, and AIUM; contact: Melvin Linzer, A366 Materials Building, 301/921-2611.

June 3
ASTM G-2 SYMPOSIUM ON FRETTING WEAR, NBS, Gaithersburg, MD; sponsored by NBS and ASTM; contact: Arthur W. Ruff, B114 Materials Building, 301/921-2966.

June 8-12
SECOND INTERNATIONAL CONFERENCE ON PRECISION MEASUREMENTS AND FUNDAMENTAL CONSTANTS, NBS, Gaithersburg, MD; sponsored by NBS, IUPAP, and AMCO; contact: Barry N. Taylor, B258 Metrology Building, 301/921-2701.

June 15-19
INTERNATIONAL JOINT CONFERENCE ON THERMOPHYSICAL PROPERTIES, NBS, Gaithersburg, MD; sponsored by NBS, ASME, and Purdue University; contact: Ared Cezairliyan, Room 124 Hazards Building, 301/921-3687.

June 18
20TH ANNUAL ACM SYMPOSIUM, University of Maryland, College Park, MD; sponsored by NBS and ACM; contact: Wilma Osborne, A265 Technology Building, 301/921-3485.

August 10-14
CRYOGENICS ENGINEERING CONFERENCE (CEC) AND THE INTERNATIONAL CRYOGENIC MATERIALS CONFERENCE (ICMC), San Diego, CA; sponsored by NBS and Cryogenic Engineering Conference; contact: Dee Belsher, Program Information Office, Room 4001-Building 1, Boulder, CO 80303, 303/497-3981.

September 14-16
SECOND INTERNATIONAL CONFERENCE ON THE DURABILITY OF BUILDING MATERIALS AND COMPONENTS, NBS, ASTM, NRC of Canada, International Council for Building Research Studies and Documentation, International Union of Testing and Research Laboratories for Materials and Structures; contact: Geoffrey Frohnsdorff, B348 Technology Building, 301/921-3485.

***October 7-9**
36TH CALORIMETRY CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and University of Colorado; contact: Robert Goldberg, A303 Physics Building, 301/921-2752.

**New Listing*

PUBLICATIONS

METRIC CONVERSION IN CONSTRUCTION INDUSTRIES

*Milton, H. J., and Berry, S. A., Metric Conversion in the Construction Industries—Technical Issues and Status, Nat. Bur. Stand. (U.S.), Spec. Publ. 598, 144 pages (Oct. 1980) Stock No. 003-003-02265-4, $5.50.**

The technical issues and status of metric conversion in the construction industries are explored in a new publication from the NBS Center for Building Technology.

Prepared at the request of the Metric Symposium Planning Committee of the National Institute of Building Sciences (NIBS), the report was presented to attendees of the NIBS symposium on Metric Conversion in the Construction Community held December 2-3, 1980.

The report contains sections on planning for the metric change, current activities in professional and industry groups, technical implications of conversion in the building sector, dimensional coordination, and metric building products and services.

The new publication also features a review of research issues, a section on timing of metric conversion in the construction sector, and a bibliography of relevant publications, standards, and handbooks. A review of policy statements issued by associations, professional societies, standards organizations, and industrial groups is included.

** Publications cited here may be purchased at the listed price from the U.S. Government Printing Office, Washington, DC 20402 (foreign: add 25 percent). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, DC 20234.*

FIRE RESEARCH SUMMARIES

Martinez, I. M., and Cherry, S. M., Eds., Fourth Annual Conference on Fire Research, Nat. Bur. Stand. (U.S.), NBSIR 80-2127, 158 pages (Oct. 1980). Available from National Technical Information Service, Springfield, VA 22161, for $11. Order by PB 81-110447.

A comprehensive outline of fire research programs at the National Bureau of Standards has just been published.

Prepared by the Bureau's Center for Fire Research (CFR), the *Fourth Annual Conference on Fire Research* (NBSIR 80-2127) provides an overview of the technical challenges that face the worldwide community of engineers, firefighters, chemists, and others who confront the problems of fire.

CFR projects outlined in the report include research on construction and materials, fire test methods, product flammability, hazard analysis, arson, and mathematical modeling. A separate section describes each of 36 CFR contracts and grants awarded to universities and private laboratories.

Sponsored by CFR on October 22 to 24, 1980, the Fourth Annual Conference on Fire Research drew representatives from a broad spectrum of research areas and from many locations nationally and internationally. Emphasis was placed on the more applied aspects of fire research including toxicology, fire tests, detection and suppression, hazard analysis, and human behavior in fires. The conference theme in alternate years is basic and applied research.

PROGRAMS FOR TESTING CONFORMANCE OF MINIMAL BASIC COMPUTER LANGUAGE

Cugini, J. V., Bowden, J. S., and Skall, M. W., NBS Minimal Basic Test Programs—Version 2. User's Manual, Volume 1—Documentation, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-70/1, 79 pages (Nov. 1980) Stock No. 003-003-02262-4, $4; and NBS Minimal Basic Test Programs—Version 2, User's Manual, Volume 2—Source Listings and Sample Output, Nat. Bur. Stand. (U.S.) Spec. Publ. 500-70/2, 487 pages (Nov. 1980) Stock No. 003-003-02263-2, $9.

A new two-volume publication describes the set of programs developed by the National Bureau of Standards for testing conformance of implementations of the computer language BASIC to the American National Standard for Minimal BASIC, ANSI X3.60-1978, adopted as Federal Information Processing Standard 68 by the Department of Commerce.

The 566-page manual (SP 500-70/1 and 2) is titled *NBS Minimal BASIC Test Programs—Version 2, User's Manual. Volume 1—Documentation* describes the nature of standardization of the BASIC language and how the tests support the standard. *Volume 2—Source Listings and Sample Output* complements the information in Volume 1 by allowing the user to examine the source code in its original form and also to get an idea of what the output from a standard-conforming implementation should look like. By submitting the programs to a candidate implementation, the user can test the various features that an implementation must support in order to conform to the standard.

While some programs can determine whether or not a given feature is correctly implemented, others produce output which the user must then interpret to some degree. The new manual describes how the programs should be used so as to interpret correctly the results of the tests.

PUBLICATIONS LISTING

Building Technology

Lew, H. S., Ed., Wind and Seismic Effects. Proceedings of the Tenth Joint Panel Conference of the U.S.—Japan Cooperative Program in Natural Resources held at the National Bureau of Standards, Gaithersburg, MD, May 23-26, 1978, Nat. Bur. Stand. (U.S.), Spec. Publ. 560, 644 pages (Oct. 1980) Stock No. 003-003-02252-7, $11.

Computer Science and Technology

Gait, J., Computer Science and Technology: Validating the Correctness of Hardware Implementations of the NBS Data Encryption Standard, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-20, 46 pages (Revised Sept. 1980) Stock No. 003-003-02249-7, $2.25.

Energy Conservation and Production

Ruegg, R. T., Life-Cycle Costing Manual for the Federal Energy Management Programs, Nat. Bur. Stand. (U.S.), Handb. 135, 234 pages (Dec. 1980) Stock No. 003-003-02274-8, $10.

Engineering, Product, and Information Standards

Guideline for Planning and Management of Database Applications, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 77, 50 pages (Sept. 1980).

Collica, J., Magnetic Tape Labels and File Structure for Information Interchange, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 79, 9 pages (Oct. 1980).

Hasko, S., Examination of Distance Measuring Devices, Nat. Bur. Stand. (U.S.), Handb. 137, 63 pages (Dec. 1980) Stock No. 003-003-02276-4, $3.75.

Walkowicz, J., Representation of Geographic Point Locations for Information Interchange, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 70, 17 pages (Oct. 1980).

Failure Analysis

Berger, H., and Linzer, M., Eds., Ultrasonic Materials Characterization. Proceedings of the First International Symposium on Ultrasonic Materials Characterization held at the National Bureau of Standards, Gaithersburg, MD, June 7-9, 1978, Nat. Bur. Stand. (U.S.), Spec. Publ. 596, 644 pages (Nov. 1980) Stock No. 003-003-02264-1, $11.

Mathematical and Statistical Methods

Goldman, A. J., and Shier, D. R., Player Aggregation in Noncooperative Games, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 5, 391-428 (Sept.-Oct. 1980).

Lewis, J. G., and Rehm, R. G., The Numerical Solution of a Nonseparable Elliptic Partial Differential Equation by Preconditioned Conjugate Gradients, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 5, 367-390 (Sept.-Oct. 1980).

Spiegelman, C. H., A Univariate Extension of Jensen's Inequality, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 5, 363-366 (Sept.-Oct. 1980).

Metrology: Physics and Radiation Technology

Day, G. W., and Franzen, D. L., Eds., Technical Digest—Symposium on Optical Fiber Measurements, 1980. Digest of a Symposium sponsored by the National Bureau of Standards in Cooperation with the IEEE Transmission Systems Sub-Committee on Fiber Optics (COMMSOC) and the Optical Society of America, held at the National Bureau of Standards, Boulder, CO, Oct. 28-29, 1980, Nat. Bur. Stand. (U.S.), Spec. Publ. 597, 148 pages (Oct. 1980) Stock No. 003-003-02239-0, $5.50.

Schoonover, R. M., A Simple Gravimetric Method to Determine Barometer Corrections, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 5, 341-346 (Sept.-Oct. 1980).

Nuclear Physics and Radiation Technology

Fowler, J. L., Johnson, C. H., and Bowman, C. D., Eds., Nuclear Cross Sections for Technology. Proceedings of the International Conference on Nuclear Cross Sections for Technology, held at the University of Tennessee, Knoxville, TN, Oct. 22-26, 1979, Nat. Bur. Stand. (U.S.), Spec. Publ. 594, 1056 pages (Sept. 1980) Stock No. 003-003-02237-3, $21.

Processing and Performance of Materials

Becker, D. A., Ed., Joint Conference on Measurements and Standards for Recycled Oil/Systems Performance and Durability. Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, MD, Oct. 23-26, 1979, Nat. Bur. Stand. (U.S.), Spec. Publ. 584, 333 pages (Nov. 1980) Stock No. 003-003-02272-1, $8.

Properties of Materials: Electronic, Magnetic, and Optical

Newbury, D., and Greenwald, S., Observations on the Mechanisms of High Resistance Junction Formation in Aluminum Wire Connections, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 6, 429-440 (Nov.-Dec. 1980).

Properties of Materials: Structural and Mechanical

Dickens, B., and Schroeder, L. W., Investigation of Epitaxy Relationships Between $Ca_5(PO_4)_3OH$ and Other Calcium Ortho-Phosphates, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 5, 347-362 (Sept.-Oct. 1980).

Standard Reference Data

Kilday, M. V., Systematic Errors in an Isoperibol Solution Calorimeter Measured with Standard Reference Reactions, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 6, 465-481 (Nov.-Dec. 1980).

Thermodynamics and Chemical Kinetics

Kilday, M. V., The Enthalpy of Solution of SRM 1655 (KC1) in H_2O, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 6, 449-463 (Nov.-Dec. 1980).

Wielopolski, P., On the Calculation of Critical Liquid-Vapor Lines of Binary Mixtures, J. Res. Nat. Bur. Stand. (U.S.), **85**, No. 6, 441-448 (Nov.-Dec. 1980).

NEWS BRIEFS

NBS, DOE ESTABLISH JOINT PROGRAM TO STUDY NUCLEAR WASTE DISPOSAL. The National Bureau of Standards and the Department of Energy (DOE) have signed a Memorandum of Understanding outlining in broad terms how NBS laboratories will support DOE's nuclear waste management programs. Under the agreement, NBS will perform research leading to the the development of new measurement techniques and standards and the collection of useful data relevant to nuclear waste management. NBS will also act as an independent measurement standards laboratory to review and evaluate certain critical test methods, reference materials, and data that form the basis for measurements in nuclear waste management operations, and will offer technical support to DOE review boards or similar groups that may be established to evaluate other nuclear waste management R & D programs.

GASES IN METALS. NBS announces the availability of five new Standard Reference Materials (SRM's) to be used in determining the concentration of gases in metals. SRM's 357 and 358 are composed of unalloyed zirconium wire with values for hydrogen and nitrogen at different concentration levels. SRM's 1086, 1087, and 1088 consist of unalloyed titanium chips certified for hydrogen only at three different concentrations. The determination of gases in metals, particularly hydrogen, is of interest to aerospace and energy fields. All five SRM's are available for sale in 10-gram units from the NBS Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, DC 20234.

NEW DEVICE EXTENDS PVT MEASUREMENTS OF FLUIDS. NBS researchers have developed a new apparatus to measure the pressure-volume-temperature (PVT) relations in hydrocarbon, chemical, and petrochemical fluids from 300 - 900 K with pressures to 35 MPa. This new device makes possible the extension of PVT measurements not previously attainable by NBS. The unit features a highly automated system of temperature measurement and control using a desktop computer and a precision ac thermometry bridge.

NICKEL-BASE TRACEALLOYS. Three new nickel-base high-temperature alloy SRM's are now certified for trace elements that have been identified by the gas turbine industry as detrimental to the performance of nickel-base superalloys. SRM's 897, 898, and 899 consist of identical alloy matrices in the form of fine millings with varying concentrations of the following elements: lead (3-15 ppm), selenium (2-10 ppm), tellurium (0.5-6 ppm), and thallium (0.2-3 ppm). Each is available at $120 per 35-gram unit through the NBS Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, DC 20234.

OPTICAL FIBERS MEASUREMENT SYMPOSIUM DIGEST. A digest of papers presented at the 1980 Symposium on Optical Fiber Measurements is now available. Included are invited papers, contributed papers, and workshops on the subjects of attenuation, bandwidth, index profile and geometric measurement, joint/defect characterization, field measurements, and standards. A limited number of copies of Technical Digest-Symposium on Optical Fiber Measurements, 1980 (SP 597) and a supplement are available at no charge from G. W. Day and D. L. Franzen, Electromagnetic Technology Division, NBS, Boulder, CO 80303.

NEXT MONTH IN

DIMENSIONS/NBS

Knowledge of little quakes aids in signaling possible big quakes that can result in rubble. April DIMENSIONS/NBS describes a more accurate device to be used in sensing small earth movements.

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Prepared by the Public Information Division
Washington, DC 20234

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Courtesy of —Washington State Department of Fisheries, page 8.
Courtesy of NOAA, NMFS, Scientific Publications Staff, pages 9 and 11-13.
Courtesy of U.S. Army Corps of Engineers, page 13, bottom.
Courtesy of Naval Surface Weapons Center, page 21.
Correction: In the January/February issue the captions on pages 20 and 21 were transposed.

The Commerce Department's National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their application for public benefit. NBS research projects and technical services are carried out by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method developments, and standards writing. DIMENSIONS/NBS describes the work of NBS and related issues and activities in areas of national concern such as energy conservation, fire safety, computer applications, materials utilization, and consumer product safety and performance. The views expressed by authors do not necessarily reflect policy of the National Bureau of Standards or the Department of Commerce.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Annual subscription: Domestic, $11.00, foreign, $13.75. Single copy: $2.25, foreign, $2.85. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.

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